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1920

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		WEST VIRGINIA	I. C. White, Morgantown.
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NEBRASKA	E. H. Barbour, Lincoln.	WYOMING	G. B. Morgan, Cheyenne.
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VALUE OF FOREIGN COINS

ESTIMATE BY DIRECTOR OF THE MINT, JAN. 1, 1921

Country.	Standard.	Monetary Unit.	Value in Terms of U.S. Gold Dollar.	Exchange Value.	Coins and Remarks.
Argentine Republic.	Gold..	Peso.....	$0.9648	Gold, $0.7725 Paper, .34	Gold: argentine ($4.824) and ½ argentine. Silver: peso and divisions. Currency: Depreciated paper, convertible at 44 per cent. of face value.
Austria-Hungary..	Gold..	Krone.....	.2026	.0025	Gold: 10 and 20 crowns. Silver, 1 and 5 crowns.
Belgium.....	Gold..	Franc.....	.1930	.0625	Gold: 10 and 20 francs. Silver: 5 francs.
Bolivia.....	Gold..	Boliviano.....	.3893	.2717	Silver: boliviano and divisions, 12½ bolivianos equal 1 pound sterling.
Brazil.....	Gold..	Milreis.....	.5462	.1375	Gold: 5, 10 and 20 milreis. Silver: ½, 1 and 2 milreis. Currency: Government paper.
British Colonies in Australasia and Africa.....	Gold..	Pound sterling.....	4.8665		
Canada.....	Gold..	Dollar.....	1.0000	.8425	
Central America: Costa Rica.....	Gold..	Colon.....	.4653	.23	Gold: 2, 5, 10 and 20 colons ($9.307). Silver: 5, 10, 25 and 50 centimos.
British Honduras.....	Gold..	Dollar.....	1.0000		
Nicaragua.....	Gold..	Cordoba.....	1.0000		
Guatemala... } Honduras.... }	Silver..	Peso.....	.9271		Guatemala: Currency, inconvertible paper. Honduras: Currency, bank notes.
Salvador.....	Gold..	Colon.....	.5000	.49	Currency, convertible into silver on demand.
Chile.....	Gold..	Peso.....	.3650	.135	Gold: escudo ($1.825), doubloon ($3.650), and condor ($7.300). Silver: peso and divisions. Currency: Inconvertible paper.
China.....	Silver	Tael.. Amoy.....	.9019		The tael is a unit of weight; not a coin. The customs unit is the Haikwan tael. The values of other taels are based on their relation to the value of the Haikwan tael. The Yuan silver dollar of 100 cents is the monetary unit of the Chinese Republic; it is equivalent to .644 + of the Haikwan tael.
		Canton.....	.8992		
		Cheefoo.....	.8626		
		Chin Kiang..	.8810		
		Fuchau.. ...	.8343		
		Haikwan (customs)	.9177		
		Hankow.....	.8439		
		Kiaochow...	.8740		
		Nankin.....	.8925		
		Niuchwang..	.8458		
		Ningpo.....	.8671		
		Peking.....	.8793		
		Shanghai....	.8238		
		Swatow.....	.8331		
		Takau.....	.9076		
		Tientsin.....	.8740		
		Dollar Yuan.....	.5910		
		Dollar Hongkong...	.5932		
		Dollar British.....	.5932		
		Dollar Mexican.....	.5976		
Colombia.....	Gold..	Dollar.....	.9733	.87	Gold: condor ($9.647) and double condor. Silver: peso.
Cuba.....	Gold..	Peso.....	1.0000		Currency, Government paper and gold.
Denmark.....	Gold..	Krone.....	.2680	.1515	Gold: 10 and 20 crowns.
Ecuador.....	Gold..	Sucre.....	.4867	.30	Gold: 10 sucres ($4.8665). Silver: sucre and divisions.
Egypt.....	Gold..	Pound (100 piasters).	4.9431		Gold: pound (100 piasters), 5, 10, 20 and 50 piasters. Silver: 1, 2, 5, 10 and 20 piasters. The actual standard is the British pound sterling, which is legal tender for 97½ piasters.

Country.	Standard.	Monetary Unit.	Value in Terms of U.S. Gold Dollar.	Exchange Value.	Coins and Remarks.
Finland	Gold	Markka	.1930	.026	Gold: 20 marks ($3.8), 5910 marks ($1.93).
France	Gold and Silver	Franc	.1930	.059	Gold: 5, 10, 20, 50 and 100 francs. Silver 5 francs. Member of Latin Union; gold is the actual standard.
German Empire	Gold	Mark	.2382	.0138	Gold: 5, 10 and 20 marks.
Great Britain	Gold	Pound sterling	4.8665	3.53	Gold: sovereign (pound sterling).
Greece	Gold and Silver	Drachma	.1930	.074	Gold: 5, 10, 20, 50 and 100 drachmas. Silver: 5 drachmas. Member of Latin Union; gold is the actual standard.
Haiti	Gold	Gourde	.2500		Gold: 1, 2, 5 and 10 gourdes. Silver: gourde and divisions. Currency: Inconvertible paper.
India (British)	Gold	Rupee*	.3244	.26	Gold: sovereign (pound sterling). Silver: rupee (15 rupees = 1 pound sterling).
Indo-China	Silver	Piaster	.5942		
Italy	Gold and Silver	Lira	.1930	.034	Gold: 5, 10, 20, 50 and 100 lire. Silver: 5 lire. Member of Latin Union; gold is the actual standard.
Japan	Gold	Yen	.4985	.482	Gold: 5, 10 and 20 yen. Silver: 10, 20 and 50 sen.
Liberia	Gold	Dollar	1.0000		Currency: Depreciated silver token coins. Customs duties are collected in gold.
Mexico	Gold	Peso†	.4985	.50	Gold: 5 and 10 pesos. Silver: dollar‡ (or peso) and divisions. Exchange value, silver peso, $1.015.
Netherlands	Gold	Guilder (Florin)	.4020	.313	Gold; 10 florins. Silver: 2½, 1 florin, and divisions.
Newfoundland	Gold	Dollar	1.0000		Gold: 2 dollars ($2.027).
Norway	Gold	Krone	.2680	.151	Gold: 10 and 20 crowns.
Panama	Gold	Balboa	1.0000		Gold: 1, 2½, 5, 10 and 20 balboas. Silver: peso and divisions.
Paraguay	Gold	Peso (Argentine)	.9648		Currency: Depreciated paper.
Persia	Gold	Achrefi	.0959		Gold: ½, 1, and 2 tomans ($3.409). Silver: 14, ½, 1, 2 and 5 krans.
	Silver	Kran	.1013		
Peru	Gold	Libra	4.8665	4.26	Gold: ½ and 1 libra. Silver: sol and divisions.
Philippine Islands	Gold	Peso	.5000	.465	Silver peso: 10, 20 and 50 centavos.
Portugal	Gold	Escudo	1.0805	.0845	Gold: 1, 2, 5 and 10 milreis. Currency: Inconvertible paper.
Roumania	Gold	Leu	.1930	.011	
Russia	Gold	Ruble	.5146		Gold: 5, 7½, 10 and 15 rubles. Silver: 5, 10, 15, 20, 25, 50 and 100 copecks.
Santo Domingo	Gold	Dollar	1.0000		
Servia	Gold	Dinar	.1930		
Siam	Gold	Tical	.3709		
Spain	Gold and Silver	Peseta	.1930	.13	Gold: 25 pesetas. Silver: 5 pesetas. Valuation is for the gold peseta; currency is notes of the bank of Spain.
Straits Settlements	Gold	Dollar	.5678	.405	Gold: sovereign (pound sterling). Silver: dollar and divisions.
Sweden	Gold	Krona	.2680	.1975	Gold: 10 and 20 crowns.
Switzerland	Gold	Franc	.1930	.152	Gold: 5, 10, 20, 50 and 100 francs. Silver: 5 francs. Member of Latin Union; gold is the actual standard.
Turkey	Gold	Piaster	.0440	.007	Gold: 25, 50, 100, 250 and 500 piasters. 100 piasters equal to the Turkish £.
Uruguay	Gold	Peso	1.0342	.752	Gold: peso. Silver: peso and divisions.
Venesuela	Gold	Bolivar	.1930	.175	Gold: 5, 10, 20, 50 and 100 bolivars. 5 bolivars.

* The sovereign is the standard coin of India, but the rupee ($0.3244⅓) is the current coin, valued at 15 to the sovereign.

† Seventy-five centigrams fine gold.

‡ Value in Mexico, *$0.4985.*

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INTRODUCTION

The object in view in the compilation of the annual volumes of THE MINERAL INDUSTRY is to bring together, in as short a time as possible after the close of the year, a review of the progress during the year in the mining and metallurgical industries. While production figures are a necessary part of any record of this character, they are not the real meat; the production figures merely make up the skeleton around which the discussion of the general conditions in any particular phase of the industry is arranged. Our desire is to combine the leading statistics with such extracts from the current literature as have a bearing on the subject in hand, and sufficient discussion of the prevailing commercial conditions to show the financial side of the industry, in order to make a well-rounded review of general progress.

There are, of course, many difficulties to be met in an undertaking of this character. In the first place, the space is limited and the various objects cannot be handled in as great detail as might be desired. While the information may not be full enough in some cases to meet the demands of the specialist, it should be sufficient to serve the purpose of most readers, and will supply foundation material for a more complete investigation of the subject if desired.

In the second place no one person can be sufficiently familiar with all of the different subjects treated to be able to do justice to the preparation of the review. For this reason, in order to make the reports as representative as possible, their preparation has been turned over to specialists in the various lines, so that the reader may get the items of information included in the report in the light of the judgment of an expert concerning them.

In the third place the volume is international in its scope. So far as is possible, the information given includes the various countries of the world producing important quantities of any particular material. It must be borne in mind, however, that the more remote the producing locality, the more difficult as a rule to get full and authoritative information. This, coupled with the fact that many of the official reports on production are published only after prolonged delays, makes the situation all the more difficult.

It is gratifying to note the degree to which the statistical bureaus of the different countries have recovered from the effects of the war. Many

countries where publication was suspended have resumed, with usually more or less information concerning the war years, and in other countries the reports are appearing more promptly. All efforts in this direction, either at home or abroad, should be heartily encouraged, and a broad dissemination of the results is bound to be a very important factor in the development, not merely of the industries concerned, but of the country as a whole. In this connection the Editor ventures to call attention again to the following paragraphs which first appeared in 1919 in an introductory chapter to Volume 25:

"These two factors, the individual interest in other localities supporting a given industry, and the interdependence of the various countries on each other for adequate supplies of certain materials, make necessary the dissemination of general information in regard to the status of the various industries from time to time. There are in the various states and countries certain organized agencies for the collection and distribution of such information, and the technical press gives a large amount of general information along these lines. But there is still room for considerable expansion along this line. Information should be fuller and more detailed, and should be made available more promptly.

"The prime requirement for the best development of domestic resources is a thorough knowledge of those resources. And for the best results this knowledge must be well disseminated and not be confined to a few people in the immediate locality. In other words, every available source of material should be thoroughly advertised—not necessarily by paid advertising—but by proper publicity in the technical press, in order that the information may be readily available to all who are interested. This condition is at present only partly fulfilled, and there is room for considerable improvement.

"And next in importance after a thorough knowledge of domestic conditions is an equally thorough knowledge concerning the various foreign sources of any given material. This is of course more difficult to secure, and information is not nearly so plentiful as for domestic conditions, and usually the more remote the locality, the more meagre is the information. Many of the disturbances of the past three years in foreign supplies of material would doubtless have been considerably lessened if importers had had a fuller knowledge of sources of materials. Too many had no information beyond their own particular source of supply. And in many cases the necessary information was very hard to secure.

"All the evidence, then, points to the necessity of fuller information concerning both foreign and domestic supplies of materials. And since it seems impossible for any country to be minerally independent, let each

at least exert a reasonable degree of care in the apportionment of its dependence, for the strain can be considerably lessened for all by a proper exchange of information. To this end, co-operation between the various agencies interested in the collection and dissemination of such information is to be encouraged and fostered to the utmost possible degree. And of course there must be some central agency for the final bringing together of the material from its various sources, and presenting it in an usable form. This is a service that THE MINERAL INDUSTRY has attempted to do for the mining and metallurgical industries for the past 25 years. The task has not been an easy one, but neither has it been a thankless one, as is evidenced in a number of ways with the appearance of each successive volume."

The material used in the make-up of this volume is from three general sources: the publications of the United States Geological Survey, Bureau of Mines, and Bureau of Foreign and Domestic Commerce, and the corresponding departments of other countries; the columns of the current technical press; and the personal knowledge and correspondence of the individual contributors.

We owe special acknowledgement to the columns of the following periodicals: *Engineering and Mining Journal, Mining and Scientific Press, Transactions of the American Institute of Mining and Metallurgical Engineers, Chemical and Metallurgical Engineering, The Coal Age, The Iron Age, American Fertilizer, Mining Journal, Mining Magazine, Canadian Mining Journal, Canadian Chemistry and Metallurgy, Queensland Government Mining Journal, South African Mining and Engineering Journal, L'Echo des Mines et de la Metallurgie, Annales des Mines* (France), and *Annales des Mines de Belgique.* An effort is made to credit to the source from which it is obtained all material taken from these or other publications; any failure in this respect is due to oversight, and not to intentional appropriation.

A number of minerals of lesser importance from a technical standpoint have not been covered in this work. This applies in particular to those connected with the pottery and building trades, whose raw materials are so widely distributed that a general report would require space out of all proportion to its value in a review of this kind. On the other hand, some industries relating to manufactured material are included, when the product is directly dependent on the production of raw minerals, or where it is being substituted for them, as in the case of cement and coke.

Since at best it requires some months after the close of the year for the collection of statistics, and often approximate figures are obtainable long before final completion, it is in many cases necessary and desirable to use such preliminary figures and estimates, with indication of the fact

that the figures are not final. These are revised in later issues by substitution of final and official data, and it is therefore of importance in using MINERAL INDUSTRY always to refer to the latest volume, even for the figures for previous years.

G. A. ROUSH.
ALLISON BUTTS.

BETHLEHEM, PA.,
July 15, 1921.

ABRASIVES

By J. Volney Lewis

The record of 1920 in the abrasive industry is exactly the reverse of that of the preceding year. Abrasives were in great demand during the first half of the year, and in some lines for several months later, showing a marked improvement over 1919; but the general slump, particularly in the last quarter, brought the industry to its lowest ebb for many years. Prices changed little, but on the whole there was a tendency toward higher prices for natural abrasives and manufactured products than during the year 1919.

One of the hardest blows to the industry, particularly the manufacture of grinding wheels, was the severe depression in the automobile business. Many thousands of wheels are consumed annually in the one operation of crankshaft grinding alone.

At the end of the year there was a widespread feeling that the industrial depression would pass in a few months by the gradual resumption of manufacturing, but this was soon replaced by a general resignation to a much longer period of readjustment. Producers say that only slight concessions in prices are possible unless production costs can also be lowered, since abrasive prices were not advanced from pre-war levels in any way commensurate with those of other commodities.

Emery and corundum for many years have not been a serious factor in the manufacture of grinding wheels, and now it is believed that they have been permanently replaced in many fields for polishing purposes also. The necessity of using artificial abrasives for nearly all grinding and polishing purposes during the war, and through much of the most active period since, has educated many former adherents of the natural materials to the use of the artificial.

The gradual monopolization of the industry by the manufactured product has been greatly promoted in the metal-working field by the production of abrasives that are adapted to a wide range of uses and by such control of the composition and the manufacturing processes as to secure a higher degree of uniformity than was ever possible with natural materials. Mineral abrasives, however, will doubtless long continue to hold a subordinate place, especially in certain polishing operations.

The tremendous growth of the foreign trade of the United States in abrasives is shown by the following comparison of imports and exports

for the fiscal years ending June 30, 1919 and 1920, with the pre-war years 1913 and 1914:

GROWTH OF FOREIGN TRADE IN ABRASIVES
(Fiscal years ending June 30)

Years.	Imports.	Exports.	Totals.
1913	$291,899	$2,311,382	$2,603,281
1914	863,171	2,114,632	2,977,803
1919	2,324,977	5,864,353	8,189,320
1920	2,254,855	5,649,177	7,903,032

EMERY

Heavy reductions occurred in the output of American emery—from New York and Virginia—in 1918 and 1919, when imported emery again became available. Production for 1916, 1917, and 1918 had been 15,282, 17,135, and 10,422 short tons, respectively. In 1919 it dropped to 2,601 tons and in 1920 to 2,327 tons. The average value fell from $14.07 per ton in 1917 to about $9.00 in 1919 and 1920.

Emery has been scarce owing to the disturbed conditions in Greece and Turkey and the continued inactivity of the mines. Prices were higher than in 1919, but the volume of the business was less. On the other hand, prices of domestic emery, most of which is greatly inferior to the imported, were lower than at any time since the signing of the armistice.

Emery will probably never again figure to any great extent in the manufacture of wheels on account of its irregular hardness, texture, and composition, which make it unreliable and unsatisfactory for precision grinding and render impossible the exact duplication of grades. For some purposes, however, it is still preferable, particularly in the aluminium industry and in optical grinding and polishing. It is also cheaper now than the artificial products, and hence it is coming back into use in some lines as a matter of economy.

Much Turkish and Greek emery is gray in color, but some manufacturers produce a semblance of uniformity by dyeing the grains black, catering at the same time to the prejudices of some consumers in favor of black emery.

New York.—The Peekskill district of Westchester County includes a number of small mines, ranging from mere prospect trenches and pits to open cuts that measure 40 by 200 to 300 ft. and of a maximum depth of about 50 ft. The total output during the four war years was about 50,000 tons of lump ore, which is more than the product of the two preceding decades.

There was a fair demand for Peekskill emery during the first half of 1920, but practically none in the second half. Shipments averaged about

a carload a month, and the total was perhaps a little more than 1000 tons. This may be considered about the normal consumption when foreign emery is available.

Greece.—The output of Naxos emery in 1920 is estimated at 11,000 tons, as compared with 9000 tons in the preceding year. France was the heaviest purchaser in 1920, the other countries in order being the United States, Italy, the Netherlands, United Kingdom, and Spain. The local industry absorbed 489 tons. On Jan. 1, 1921, reserves at Syra and the Gulf of Naxos amounted to 9206 metric tons.

Complaint is made of the scarcity and inefficiency of the mine labor. The Greek Government is said to be taking steps to raise wages, with a view to increasing the individual output. Another source of trouble is the exhaustion of some of the more accessible deposits and the difficulty of mining at greater depths with primitive methods and equipment. Efforts are being made to locate other deposits, but eventually scientific methods will have to be applied if the industry is to be maintained.[1]

Corundum

No corundum has been produced in either the United States or Canada since the decline of the abnormal demand and prices of the war period. In 1917 North Carolina produced 820 tons. Railway shipments of 195 tons of corundum in Canada were recorded during 1920, but none was mined.

Owing to the high costs of mining, cleaning, crushing, and preparing the material for the market, the difficulty of maintaining a uniform standard of purity, and the handicap of long overland shipment, these deposits can no longer compete with the electric furnace.

Total imports of corundum ore and grains in 1920 amounted to 3374 long tons, valued at $361,029, as compared with 3245 tons worth $305,832 in 1919, a gain of less than 4 per cent. in quantity and more than 15 per cent. in value.

Transvaal.[2]—The corundum fields of the northern and eastern Transvaal are some 2000 sq. mi. in extent, situated in the Pietersburg and Zoutpansberg districts, extending from Pietersburg northward to Zoutpansberg and from Sand River eastward to the Knopneuzen Location and southeastward across the Low Country to the junction of the Malelane and Olifants rivers. The last named portion extends over the Olifants River mica fields. In the Plateau region the most productive centers lie around Bandolierkop and Mara, served by the Messina railway; in the Low Country the Selati railway serves the various workings, situated mainly east of Mica Siding.

[1] *Suppl. to Comm. Rept.*, Nov. 30, 1920; June 11, 1921.
[2] A. L. Hall, *Memoir Geol. Surv. Union So. Afr.*; *So. Afr. Min. Eng. Jour.*, Dec. 18, 25, 1920.

Granitic and gneissic rocks are the principal formations, but in them are found a large number of small patches of basic magnesian rocks—serpentines, pyroxenites, peridotites. Corundum occurs only in these basic rocks, and these are the sources of the superficial crystals and boulders which have furnished the chief production thus far.

The corundum reef rock is a white coarse-grained feldspar with scattered crystals of gray or greenish-gray corundum (plumasite) in the Plateau region and in the transition belt; in the Low Country it is a similar rock in which margarite takes the place of feldspar (marundite). The alluvial deposits of crystal corundum have been chiefly exploited. Boulder corundum, consisting of boulders of the reef rock, was shipped during the war. Mining from the reef rock has been attempted only on a small scale.

Open-cut methods are used, the maximum depth so far attained being about 40 ft. Large quantities of surface corundum are still available, and commercial plumasite and marundite orebodies are estimated to carry from 30 to 60 per cent. of corundum. Deposits in one or the other form have already been proved on about 100 farms and many more will probably be discovered, while the limits of the field are not yet defined.

The origin of the corundum is ascribed to contact metasomatic changes in granite-pegmatite magma intrusive in basic magnesian rocks; the latter, taking up the silica, have caused a relative excess of alumina, which separated as corundum. The abstracted silica appears in the talcose zone and the casing of vermiculite inclosing the corundiferous reef. With further magmatic and probably pneumatolytic changes the corundum in plumasite becomes surrounded by a reaction rim of gibbsite or margarite, formed from corundum and plagioclase, thus leading to marundite. The deposits are in many ways like those of the eastern United States and like certain deposits in serpentine near Krantzkop in Natal.

These are characterized as the most extensive and the richest corundum deposits in the world and are thought to offer the basis for a valuable industry, notwithstanding the severe competition of artificial abrasives. Among the conditions to be met are uniform methods of grading, maintenance of a definite and a high standard of purity, and closer contact between producer and consumer. Export of graded corundum in grain form is recommended instead of the present shipments of crystal corundum, with uncertain proportions of gangue.

The pre-war production of 111 tons in 1912 is contrasted with 3875 tons in 1918. The Steinkopf deposits in Namaqualand are exploited on a modest scale. South Africa exported to the United States, during

1919, 513 tons of corundum ore valued at $123,351, and 136,210 lb. of corundum crystals valued at $9,538.[1] Madagascar exported a total of 824 metric tons in 1919.

Grindstones and Whetstones[2]

The production of grindstones in the United States in 1920 amounted to 44,832 tons, valued at $1,239,990, as compared with 40,755 tons, worth $993,959, in 1919. These range, for various purposes, from less than ¼ in. to 6 or 7 ft. in diameter, and from less than a pound to 1 or 2 tons in weight. The average value was $27.66 per short ton in 1920, as against $24.39 in 1919.

Stones used for grinding wood into fine fiber for pulp and paper are known as pulpstones. These are generally 54 in. in diameter and 27 in. thick and weigh about 2 tons, although some machines require stones weighing about 4 tons. The production in 1920 was 8652 tons, valued at $467,014; in 1919 it was 6110 tons, valued at $342,056. The average value was $54 per ton in 1920 and $56 in 1919.

Grindstones and pulpstones were produced from sandstone quarries in Ohio and West Virginia, and grindstones also in Michigan.

The total sales in 1920 of oilstones, whetstones, scythestones, hones, and rubbing stones were 1144 short tons, valued at $231,747. The corresponding figures for 1919 were 1463 tons, valued at $235,943. The values given are for the manufactured product. Stone for the oilstones and whetstones was quarried in Garland County, Ark.; Floyd and Orange counties, Ind.; and Scioto County, Ohio. The scythestone material came from Grafton County, N. H.; Cuyahoga and Scioto counties, Ohio; and Orleans County, Vt. The rubbing stones were produced in Floyd County, Ind., and Lorain County, Ohio; and the hones in Hardin County, Ky.

Pumice[3]

The world's chief source of pumice is the island of Lipari, off the north coast of Sicily and about 40 miles from the Italian mainland. In normal times the town of Lipari, having about 10,000 inhabitants, collects export duty of about 300,000 lire annually from the pumice industry.

Primitive mining methods are used. The material near the surface is extracted by drifts a few meters into the hillside. These openings are without timbering and have to be abandoned long before the possibilities of extraction are exhausted. Before the war most of the work was done by convicts, who had no interest in it, and the grinders turned out inferior

[1] *Suppl. to Comm. Rept.*, Aug. 16, 1920.
[2] U. S. Geol. Surv. *Press Bull.*, May, June, 1921.
[3] *Comm. Rept.*, Aug. 18, 1920.

material. During the war the convicts were sent to another island and the natives now do the work better; but the native-ground pumice is still inferior, so the crude lump brings higher prices than the ground in the American market. Roughly three grades are produced:

1. Crude pumice as taken from the mines—"pumice chips," or "pezzame," constituting about 80 per cent. of the export to the United States, the only country that imports and grinds the crude.

2. Italian powdered pumice, from local mills, exported in bags—much inferior to American ground pumice, but constituting the bulk of the export to Great Britain, France, and other countries.

3. Lump pumice, from the size of an apple to a large cabbage, shipped in barrels and used by auto- and carriage-makers, marble-workers, lithographers, platers, and manufacturers of patent leather and enamel.

Exports dwindled during the war, but were greater than ever in 1919, as follows:

	Kilograms.
To the United States	7,531,693
To Italy and Sicily	5,805,684
To France	3,257,148
To England	1,451,381
To Germany	198,369
Total exports	18,244,275

It is understood that one firm shipped 4,000,000 kilos to the United States in the first half of 1920. About twenty firms on the island are engaged in the export trade and competition is active.

The industry needs modern methods and mechanical devices for grinding and preparation of the raw material. It is also handicapped by the lack of shipping facilities. Ocean vessels seldom stop at Lipari, since there is no harbor. Pumice is occasionally lightered out to steamers on small barges, but the bulk of it is handled through the port of Messina, in Sicily. Often low rates can be secured on vessels returning to the United States from Adriatic and Black Sea ports.

Abrasive Diamond

The Brazilian carbonado and diamond industry was seriously interfered with during 1919 by strikes and other labor difficulties. Over 50 per cent. of the output was exported to the United States, about 40 per cent. to England, and the rest to the Netherlands and France. The value of carbonados exported to the United States in 1919 was $530,170, as contrasted with $11,135 in 1913. The corresponding figures for rough diamonds were $471,181 in 1919 and $14,920 in 1913.[1]

The total importations of diamond dust and bort in 1919 amounted to $1,420,442. This was more than three times the amount for 1918 and

[1] *Comm. Rept.*, Nov. 24, 1920.

the largest on record. These figures were again more than doubled in 1920, when the value of imports increased to $3,387,488.

Artificial Abrasives

During the first half of 1920 the volume of business in artificial abrasives exceeded all previous records, including the maximum production during the war. There was a severe decline, however, in the later months of the year, and by December the furnaces were producing only about 25 per cent. of their capacity.

During 1919 the prices of artificial abrasives were advanced somewhat more than 20 per cent., but there were no changes of consequence in 1920. Manufacturing costs, however, increased sharply, owing chiefly to higher freight-rates, the freight in some cases exceeding the value of the raw material at its source. Figures for domestic production in 1920 are not available, but artificial abrasives were imported in that year to the amount of 69,088,995 lb., valued at $1,751,092. In the year 1918, 19 per cent. of the bauxite mined in this country was used in the manufacture of abrasives.

Canadian Abrasive Co.—A new industry is announced for Canada in a line which has hitherto been controlled by the United States. The Provincial Department of Industries of British Columbia has lent the sum of $22,000 to the Canadian Abrasive Co., which will establish an experimental plant in Victoria for the manufacture of abrasive papers—sand, emery, etc. Local abrasives and paper from local mills will be used.[1]

Diaspore Clay in Missouri[2]

Diaspore has been found to be the chief constituent of beds associated with flint clay along the C. R. I. & P. railroad in Franklin, Gasconade, and Maries counties, Mo. The material was formerly discarded because of its rough texture and the blistering and distortion it caused when fired. It was considered detrimental or worthless and large bodies of it were left in abandoned pits. It is frequently found as a core near the center of the flint clay and as rounded boulders in the overlying weathered clay.

Dr. W. S. Cox, for several years a producer of flint clay, had samples analyzed and discovered its true nature. One analysis gave SiO_2, 9.30 per cent.; Al_2O_3, 73.73; Fe_2O_3, 0.57; Na_2O, 2.00; K_2O, 0.52; H_2O, 14.00; moisture, 0.60; total, 100.72 per cent. In texture the diaspore clay ranges from compact hard blue or gray flint clay with scattered flecks of white or bluish white and an occasional minute oölite, through a

[1] *Can. Min. Jour.*, July 30, 1920.
[2] Bienn. Rept. State Geologist, 1919, pp. 17–20. *Am. Mineralogist*, **2**, 144 (1917); **3**, 154 (1918).

true oölitic form to a rough, porous, ash-colored mass, not unlike the light-colored varieties of bauxite. Red varieties are also found. It is made up of particles and oölites of diaspore (AlO.OH) embedded in a little flint clay.

Commercial shipments were begun about the first of 1918. It is refined and bonded as an abrasive and is used in the manufacture of refractories. It is thought it may also become a source of aluminium ore.

STATISTICS

HIGH-GRADE ABRASIVES IN THE UNITED STATES, 1913–1920
(In short tons)

	Domestic.		Imported Emery and Corundum.	Total Mineral Abrasive.		Artificial Abrasives.			
						Domestic.		Imported Value.	Total Value.
	Garnet.	Emery and Corundum.		Tons.	Value.	Tons.	Value.		
1913	5,308	957	20,425	26,690	$645,802	16,744	$2,017,458	$190,290	$2,207,748
1914	4,231	485	14,457	18,968	508,800	15,830	1,685,410	233,799	1,919,209
1915	4,301	3,895	10,116	17,480	435,732	18,842	2,248,778	255,474	2,504,252
1916	6,171	15,282	9,252	30,705	533,976	38,806	2,935,909	940,219	3,876,128
1917	4,995	17,135	2,250	24,380	649,979	57,911	8,137,242	1,758,910	9,896,152
1918	4,600	10,422	9,548	24,666	975,206	.....	.....	1,962,280	.....
1919	4,944	2,601	12,846	20,391	928,537	.....	.....	1,241,059	.....
1920	5,476	2,327	9,824	17,627	1,073,297	.....	.....	1,751,092	.....

EMERY PRODUCED IN THE UNITED STATES, 1913–1920
(U. S. Geological Survey)

Year.	Short Tons.	Value.	Average per Ton.
1913	957(a)	$4,785(a)	$5.00(a)
1914	485(a)	2,425(a)	5.00(a)
1915	3,063(a)	31,131	10.17(a)
1916	15,282	123,901	8.11
1917	17,135(b)	241,050(b)	14.07(b)
1918	10,422(c)	112,878(d)	10.83(d)
1919	2,601	23,203	8.92
1920	2,327	21,685	9.32

(a) Estimated. (b) Includes 820 short tons of corundum from North Carolina, valued at $67,461, or $82.28 per ton; the emery alone averaged $10.64 per ton. (c) Includes North Carolina corundum. (d) Value of marketed material.

IMPORTS OF EMERY INTO THE UNITED STATES, 1913–1920
Years ending June 30, (Bureau of Foreign and Domestic Commerce)

	Ore.		Grains.		Manufactures Value.	Total Value.
	Long Tons.	Value.	Pounds.	Value.		
1913	18,964	$328,211	922,660	$37,307	$15,067	$380,585
1914	14,197	275,973	844,157	33,874	20,874	330,721
1915	7,194	152,088	629,581	25,011	.....	177,099
1916	10,255	194,954	461,461	18,712	35,142	248,808
1917	2,000	14,282	136,969	7,889	33,535	55,706
1918	3,609	88,875	482,289	32,371	44,390	165,636
1919(a)	8,302	235,596	392,789	22,432	41,039	299,067
1920(a)	5,398	222,321	.....	.....	.....	.....

(a) For the calendar year.

IMPORTS OF CORUNDUM INTO THE UNITED STATES, 1913-1920
Years ending June 30, (Bureau of Foreign and Domestic Commerce)

	Ore.		Grains.		Total Value.
	Long Tons.	Value.	Pounds.	Value.	
1913	541	$78,401	1,937,803	$87,187	$165,588
1914	294	39,772	1,114,051	61,026	100,798
1915	183	23,701	831,350	39,914	63,615
1916	17	633	657,826	29,471	30,104
1917	283	27,503	2,310,594	128,941	156,444
1918	1,182	119,522	3,421,454	189,345	308,867
1919(a)	3,168(a)	296,136	154,560	9,696	305,832
1920(a)	3,374(a)	361,029	.....	.....	361,029

(a) Ore and grains, for the calendar year.

COMPARATIVE VALUES OF IMPORTS, 1913-1920
Years ending June 30, (Bureau of Foreign and Domestic Commerce)

	Corundum.	Emery.	Combined Value.	Artificial Abrasives.
1913	$165,588	$380,585	$546,173	$190,290
1914	100,798	330,721	431,519	233,799
1915	63,615	177,099	240,714	255,474
1916	30,104	248,808	278,912	547,948
1917	156,444	55,706	212,150	1,370,063
1918	308,867	165,636	474,503	1,856,734
1919(a)	305,832	299,067	604,899	1,241,059]
1920(a)	361,029	222,321	583,350	1,751,092

(a) For the calendar year.

ABRASIVES EXPORTED FROM THE UNITED STATES (a)

	1916.	1917.	1918.	1919.	1920.
Wheels, emery and other.....	$2,240,227	$4,881,600	$3,862,531	$3,032,067	$2,791,128
All others.....	2,035,951	1,941,512	1,982,822	2,809,231	3,810,171
Totals.....	$4,276,178	$6,823,112	$5,845,353	$5,841,298	$6,601,299

(a) Bureau of Foreign and Domestic Commerce.

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Garnet

By D. H. Newland

Garnet for abrasive uses is obtained in New York, New Hampshire and North Carolina, with minor quantities occasionally coming from other states and irregular shipments from abroad. Spain seems to be the only foreign country which contributes materially to the supply and its product consists of from 1000 to 1500 tons a year of garnet sand obtained from alluvial workings, all or most of which is exported to the United States for manufacture into abrasive papers and cloth. This industry is altogether an American development and finds support mainly in the domestic trade. With the recognized qualities which garnet possesses for certain kinds of work, it seems rather surprising that it has not found wider employment; as a matter of fact consumption for the last 15 or 20 years has been stabilized, showing little or no expansive tendency even under the most favorable conditions in regard to supplies and prices. During the recent period of high prices, with crystal garnet quoted at around $90 a ton, sales have been about the same as in earlier years when the mineral brought $30 to $35 a ton. This condition is traceable probably to the fact that garnet finds rather limited application compared with quartz, emery, or some of the artificial abrasives, yet in its particular field enjoys a degree of favor with consumers which makes it relatively independent of market fluctuations.

The principal sales of abrasive garnet materials are made to the leather and wood-working industries. The advantages of garnet for such work can not be attributed solely or predominantly to the quality of hardness, for it is inferior to emery, carborundum and several other abrasives in that respect, but probably depend upon the combination of toughness, form of grain and adhesion to the paper, as well as upon relative hardness. It is also to be noted that there is a wide variation in the abrasive qualities of different kinds of garnet and even of the same species of garnet from different occurrences. The best results are obtained from mineral that has a well-defined crystal structure—not necessarily showing crystal boundaries—which is indicated by a fairly distinct cleavage producing particles of rhombic shape with chisel-like cutting edges. Almandite is the variety commonly employed.

The consumption of abrasive garnet averages about 6500 tons a year. The accompanying table covering the mine shipments shows that the domestic product available for use has ranged in recent years from a minimum of 4231 tons in 1914 to 6171 tons in 1916, while the imports of Spanish mineral have averaged 1200 to 1500 tons, except in 1918 and 1919 when they were practically discontinued.

MARKETED PRODUCTION OF ABRASIVE GARNET IN THE UNITED STATES (a)
(Short tons)

Year.	Quantity.	Value.	Year.	Quantity.	Value.
1909	2972	$102,315	1915	4301	$139,584
1910	3814	113,574	1916	6171	208,850
1911	4076	121,748	1917	4995	198,327
1912	4947	163,237	1918	4600	242,400
1913	5308	183,422	1919	4944	310,131
1914	4231	145,510	1920	5476	434,425

(a) U. S. Geol. Surv.

Figures covering the mine shipments for 1920 total 5476 tons, considerably higher than the shipments for the preceding year and the second highest recorded. The Adirondack district by itself produced 5042 tons, and the shipments from there were probably not much under the production, inasmuch as the market was nearly depleted of stocks and Spanish garnet was not available to the same extent as formerly. The market situation may be inferred from the prices paid for American crystal, which were around $85 to $90 for the best grades. This was nearly 50 per cent. above the average prices received for the year 1919. On the basis of the Government statistics included in the table, the average value of the garnet shipped in that year was $62.73 a ton, as compared with $82.70 in 1918, $39.70 in 1917 and $33.88 in 1916. In earlier years the prices were practically stable at $30 to $35 a ton. The large increase probably no more than measures the rise in costs of production, which reached its culmination last fall under conditions altogether unprecedented.

In the Adirondack region the active producers last year were the same as heretofore with the addition of the American Glue Co., which made a small output as an experiment in its new mill on Casey Mountain. The plant has been under construction since 1918. The property was formerly known as the Crehore mine and is on the Indian Lake road, 10 miles west of North Creek. A small output was made intermittently by hand-picking the rock after drilling and blasting, in the same manner as practiced on Gore Mountain, although the garnet crystals are much smaller than in the latter locality. This is the third mill of the kind in the district and in full operation may be expected to add materially to the productive capacity. So far, however, the full capacity of the quarries and mills has not been required to meet the needs of the American market.

ALUMINIUM AND BAUXITE

ALUMINIUM

BY J. W. RICHARDS

The year 1920 was favorable for aluminium for the first six months, but the industry slumped during the second half of the year. Various and contradictory reasons have been put forward to explain these facts. In the writer's opinion the chief factor was the stopping of buying by the general public, in the hope that prices would fall faster and further than they really did. Merchants were wary about stocking up on a falling market, and adopted a hand-to-mouth policy. Outputs were normal the first six months and fell off 25 to 50 per cent. the second six months; in a few cases the manufacturers piled up unsold stock in the latter period.

The price of No. 1 metal at New York was kept steady by the manufacturers at 32 to 33 cts. per lb., but the prices of manufactured articles fell off considerably the latter half of the year.

No official figures have been given out concerning the amount of aluminium manufactured in 1920 in any country. Our own Geological Survey has not published official figures for many years, and even the British Mineral Resources Bureau has no official figures to give for Great Britain. It is highly regrettable that such an important metallurgical industry as this should have its vital statistics shrouded in mystery; but such is the policy of those controlling the information, and the general public has no reply except to regret the situation and refuse sympathy to the manufacturers when they appear before legislators asking favors.

ESTIMATED WORLD'S PRODUCTION OF ALUMINIUM
(In metric tons)

Year.	Austria.	Canada.	France.	Germany.	Great Britain.	Italy.	Norway.	Switzerland.	United States.	Total.
1913	5,000	5,916	(a)13,503	800	10,000	(a) 874	2,500	10,000	29,500	78,093
1914	4,000	6,820	(a) 9,967	800	8,000	(a) 937	2,500	10,000	40,600	82,924
1915	2,500	8,490	(a) 6,020	2,000	6,000	(a) 904	3,500	12,500	45,000	86,914
1916	5,000	8,800	(a) 9,604	8,000	4,000	(a)1,126	6,000	15,000	63,000	120,230
1917	5,000	11,800	(a)11,066	15,000	6,000	(a)1,740	8,000	15,000	90,700	164,306
1918	8,000	15,000	(a)12,023	25,000	14,000	(a)1,715	7,500	15,000	102,000	200,328
1919	5,000	15,000	(a)12,200	15,000	10,000	(a)1,673	4,000	15,000	90,000	167,874
1920	2,000	10,000	10,000	10,000	7,116	(a)1,200	4,000	12,000	90,000	146,316
Estimated Capacity....	10,000	15,000	20,000	40,000	14,000	8,000	20,000	15,000	115,000	257,000

(a) Official figures.

France and Italy have set the commendable example of giving official figures, but the other seven producing countries are still "darkest Africa" along these lines. As long as such reliable and official information is not at hand, the uninformed public and their legislative representatives cannot be expected to act towards these industries with the highest wisdom.

Distributing the output by firms, we have as a first approximation:

	Metric Tons.
Aluminum Company of America Northern Aluminium Co. of Canada	100,000
British Aluminium Co. (Great Britain and Norway)	8,116
The Aluminium Corporation, Limited	1,000
L'Aluminium Francaise (France and Norway)	12,000
Aluminium Industrie Aktien Gesellschaft (Switzerland and Austria)	14,000
L'Aluminio Italiano (Italy)	1,200
German Government Works	10,000
	146,316

IMPORTS OF ALUMINIUM INTO THE UNITED STATES (*a*)
(By fiscal years ending June 30)

Country from Which Exported.	1914. Pounds.	1915. Pounds.	1916. Pounds.	1917. Pounds.	1918. Pounds.	1919. Pounds.
Austria-Hungary	1,300,717	264,552	*Nil.*	*Nil.*	*Nil.*	*Nil.*
Belgium	227,563	194,708	*Nil.*	*Nil.*	*Nil.*	*Nil.*
France	2,081,468	1,798,127	*Nil.*	*Nil.*	*Nil.*	2,168,963
Germany	1,632,226	11,133	*Nil.*	*Nil.*	*Nil.*	*Nil.*
Italy	8,816	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*
Netherlands	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*
Norway	1,173,800	2,046,168	*Nil.*	*Nil.*	*Nil.*	223,995
Portugal	*Nil.*	4,321	*Nil.*	*Nil.*	*Nil.*	*Nil.*
Switzerland	2,612,747	264,552	*Nil.*	*Nil.*	*Nil.*	*Nil.*
United Kingdom	2,110,257	1,675,616	21,876	120	*Nil.*	2,864,642
Canada	4,816,067	7,499,313	8,148,309	1,879,859	1,794,018	12,383,379
Mexico	*Nil.*	*Nil.*	1,521	11,792	121	*Nil.*
Central America	*Nil.*	*Nil.*	528	955	38	*Nil.*
West Indies	381	150	2,043	6,655	5,985	2,990
South America	*Nil.*	6,532	26,251	4,619	*Nil.*	*Nil.*
Other Countries	*Nil.*	*Nil.*	*Nil.*	*Nil.*	274	35
Total	15,964,042	13,765,172	8,200,528	1,904,000	1,800,436	17,644,004

(*a*) Calendar years after 1917.

PRODUCTION, IMPORTS AND VISIBLE SUPPLY OF ALUMINIUM IN THE UNITED STATES

	Production.			Imports.			Exports.	Visible Supply. (*b*)
				Crude.		Mfrs.		
	Pounds.	Market Value.	Per Pound.	Pounds.	Value.	Value.	Value.	Pounds.
1905	11,350,000	$3,632,000	$0.32	530,429	$106,108	$33	$290,777	11,880,000
1906	14,350,000	5,166,000	0.36	770,713	154,292	1,866	364,251	15,121,000
1907	26,000,000	10,920,000	0.42	872,474	181,351	1,124	304,938	26,872,000
1908	13,000,000	4,095,000	0.315	465,317	80,268	2,334	330,092	13,465,000
1909	15,000,000	3,345,000	0.223	5,109,843	745,963	12,878	567,375	20,110,000
1910	12,000,000	2,736,000	0.228	12,271,277	1,844,830	.....	949,215	24,271,000
1911	(*e*)28,600,000	5,720,000	0.20	(*d*)4,173,308	598,272	(*d*)63,899	1,158,603	32,773,000
1912	(*e*)40,000,000	9,200,000	0.23	22,759,937	3,092,889	428,182	1,347,621	62,760,000
1913	(*e*)64,900,000	13,600,000	0.21	23,185,755	3,905,977	1,090,229	966,094	88,086,000
1914	(*e*)90,000,000	16,740,000	0.186	16,241,340	2,729,383	1,308,036	1,546,510	106,241,000
1915	(*e*)99,000,000	31,581,000	0.319	8,534,834	1,511,988	301,863	3,682,117	107,535,000
1916	(*e*)139,000,000	47,260,000	0.34	6,646,385	1,729,298	55,864	15,419,134	145,646,000
1917	(*e*)200,000,000	74,000,000	0.37	58,703	18,084	57,461	14,586,467	200,059,000
1918	(*e*)225,000,000	74,250,000	0.33	1,800,436	569,150	39,114	10,869,388	(*c*)202,665,000
1919	(*e*)198,000,000	63,756,000	0.322	17,644,004	5,810,557	318,407	3,890,326	(*c*)210,624,000
1920	(*e*)198,000,000	64,350,000	0.325	40,074,132	11,880,176	2,554,097	5,630,520	(*c*)228,666,000

(*a*) Not reported. (*b*) Production plus imports. (*c*) Exports deducted. (*d*) From July 1 only. (*e*) Estimated.

United States.—"Aluminum Man" writing in *The Metal Industry* for January, 1921, states that the price on contract remained stationary during 1920 at 33 cts. per lb., and that the capacity of the works is much greater than the demand. There was a good business during the year in aluminium for electrical conductors, for culinary utensils, and, in the form of the alloy duralumin, for motor, airplane, and similar uses; also as foil, plain and printed, and as leaf, especially in the form of "bronze powder" for white metallic paint. The latter is highly successful for reducing radiation from boilers, furnaces, and hot-water pipes, but plumbers make a colossal mistake by putting it on radiators.

The alloy 17 S, made by the Aluminum Co. of America, is said to be similar in properties to duralumin, and is sold in the form of sheets, rods, tubes and manufactured shapes.

The very large rolling mill of the Aluminum Co. of America at Alcoa, Tenn., near to the large manufacturing plant at Marysville, was put into operation in August; the rolling mill of the same company at Edgewater, N. J., intended to supply the eastern market, was ready to start operating early in 1921.

Rumors were prevalent in 1920 that the Anaconda Copper Co. would enter on the manufacture of aluminium. The writer is reliably informed that this company experimented on its production, but did not enter upon its commercial manufacture.

Attempts were made during 1920 to persuade Congress to increase the duty on aluminium ingots from 2 to 7 cts. per lb., and on sheets from 3.5 to 11 cts. per lb. The proposals were vigorously contested and have not yet gotten into the tariff schedule.

About 6000 short tons (5000 metric tons) of secondary aluminium is recovered yearly in the United States by remelting of scrap and skimmings, while about 12,000 short tons (10,000 metric tons) of aluminium alloy (mostly alloy No. 12 of the Aluminum Co. of America) is similarly recovered and put back to useful work. Analysis of such a sample of secondary aluminium is given by J. P. Dunlop as follows:

	Per Cent.
Aluminium	98.75
Copper	0.16
Silicon	0.11
Iron	0.56
Manganese	0.42
	100.00

Dr. R. B. Moore, Chief Chemist of the Bureau of Mines, has had two men working on the losses of aluminium during remelting. He estimates that this line of work should receive a yearly appropriation of $30,000 from the Government, in order to extend it to the cheap manufacture of

alumina, working up of by-products, improvements in manufacture, improvements in electrodes, better methods of working, etc.

Bulletin No. 5 of the Engineering Experiment Station at the University of Washington, Seattle, Wash., written by Chas. D. Grier, discusses the possibility of manufacturing aluminium by hydro-electric power at The Dalles of the Columbia River. The conclusion arrived at is that it could not be made to pay at the present time.

Great Britain.—The British Aluminium Co. held a stockholders' annual meeting on Mar. 30, 1920, and declared 10 per cent. annual dividend on the common stock. The reserve account had increased to £520,414, which it was proposed to reduce to £120,000 by a bonus distribution. Costs of production had risen, bauxite was getting scarcer, and the French Government was considering an export tax on bauxite, which would make matters worse. The company's power scheme at Orsières, in Switzerland, was halted during the war, but work was resumed on it in 1919.[1]

France.—The Compagnie des produits d'Alais et de la Camargue (Pechiney; capital 80,000,000 francs) has absorbed the Société Electrometallurgique Française (Froges; capital 50,000,000 francs). The new combination will control 90 per cent. of the production of aluminium in France, and has also large interests in Italy and Norway.

The new company will have in the valley of the Arc, from Modane to Epierre, four large works, at La Praz, La Saussaz, Calypso and St. Jeanne de Maurienne, and installations at St. Felix de Maurienne, Pontamafrey and Epierre. Not 20 years ago, they had only one small works, at Calypso on the Valloirette, making 200 to 300 tons of aluminium per year. Added to these four large plants are the smaller works of l'Argentière (Basses-Alpes), Auzat (Ariège), Chedde (High Savoie), and the alumina works of Salindres, Gardarme, St. Auban and St. Louis-les-Aygalades.

The new combination will have over 200,000 hp.[2]

Norway.—Official statistics of exports to other countries, in metric tons, are as follows:

	Tons.		Tons.
1912	1,140	1916	4,488
1913	2,177	1917	7,601
1914	2,942	1918	6,835
1915	2,883	1919	3,120

Of the exports in 1914, one-third went to the United States and the rest to Great Britain, Sweden and Germany; the 1916 exports were almost all to Great Britain.

Attempts are now being made by the A. S. Elecktrokemisk Industri to use the Söderberg continuous electrode in the aluminium pots. As

[1] *Jour. Soc. Chem. Ind.*, Apr. 15, 1920.
[2] *Jour. du Four Electrique*, June 1, 1920.

operated in Norway, some electrodes are used 18 in. in diameter, carrying 2000 amperes, and these can very probably be replaced by the continuous self-baking electrodes encased in a sheet-aluminium shell, which will reduce greatly the electrode cost and perhaps also the electrode consumption, because of the protection from oxidation furnished by the metal shell.

The industries were nearly stagnant during 1920 because of labor troubles and lack of raw materials. The works at Eydehavn and Tyssedal command 55,000 hp., but their production was irregular and very small. The plant of the Norsk Aluminium Co. at Hoyangfaldene (Sagne) stopped because of lack of alumina. This company has obtained a concesssion to mine bauxite in Surinam, Dutch Guiana, which may remedy the raw-material situation. This company lost 1,336,000 kroner during the year.

Germany.—The Innwerk, a hydro-electric aluminium development in Bavaria, near Munich, was under construction in 1920, but how near it came to completion is not yet stated. It is also not yet known how nearly completed was the large works building at Lauterwerk. It is estimated that about 400,000,000 marks was invested by Germany in aluminium works during the war.

Metallurgical Notes

Bauxite.—The United States production of about 600,000 long tons (610,000 metric tons) would contain about 150,000 long tons of aluminium, and assuming 25 per cent. of the bauxite to be used for chemical purposes (probably an over-estimate), the remainder would reduce to 115,000 tons of aluminium. This takes no account of bauxite from France or Guiana; the alumina extracted supplies reduction plants in the United States and Canada.

A modification of the Baeyer process of producing alumina from bauxite is proposed in French patent No. 591,835 of Mar. 7, 1916, granted to the Société Electrometallurgique Française. Red bauxite of the Var is charged with limestone into a blast-furnace, with 45 per cent. of its weight of coke. Pig iron is obtained and a calcium-aluminate slag, which is granulated in water. This material is used to prepare alumina by the Baeyer process.

Reduction to Metal.—G. Mortimer, in describing the aluminium industries of Europe, gives the following details not usually known: The carbon anodes used are round, square or oblong (some used in Norway are octagonal), and are 3 to 10 in. in diameter (the Norwegian up to 18 in.). The current applied is 25 to 50 amp. per sq. in. The anode connection is either a metal socket embedded into the anode during its

manufacture, into which the anode rod is screwed, or the latter is simply screwed into the anode, or fastened into a hole in the anode by casting in with melted bronze. By the latter arrangement the stump of an anode may be almost all used up. The cathode connection is usually to a heavy grid of iron or graphite, embedded in the floor of the lining and baked with it. Sometimes heavy graphite electrodes are run through the bottom, and baked hard in place, connection being made with their outer ends. The net consumption of anodes is sometimes as low as 1 lb. per pound of aluminium produced, when the butt ends are entirely consumed.

The bath material is said to be 33 per cent. cryolite, 20 per cent. calcium fluoride and 44 per cent. aluminium fluoride, which has a melting point of 800° C. and dissolves 15 per cent. of alumina. Addition of sodium chloride is sometimes made, as a temporary measure, to get the bath working quickly, reducing the melting point to 700° C. The salt, however, gradually volatilizes and disappears from the bath. The consumption of bath material is 25 per cent. of the metal produced. The ampere efficiency may reach 90 to 95 per cent., but averages for a year not over 85 per cent. The largest pots take 20,000 amp.

Properties.—J. D. Edwards and T. A. Moormann, two physical chemists with the Aluminum Co. of America, have published[1] results of careful determinations of the density of aluminium from 20 to 1000° C., using a graphite densimeter devised by Frary and Edwards for liquid metal. Metal analyzing 99.75 per cent. aluminium was used. The density as cast, in pig, was 2.686; this was increased by rolling to 2.703, but annealing produced no further change. The working increases density by the elimination of voids.

The experimental results are:

Solid.		Liquid.	
Temperature, C°.	Density.	Temperature, C°.	Density.
20	2.703	658.7	2.382
100	2.69	700	2.371
200	2.67	800	2.343
400	2.62	900	2.316
658.7	2.55	1000	2.289
		1100	2.262

The solidification shrinkage, or volume change on freezing, is close to 6.6 per cent.

J. P. Dunlop gives the commercial specifications of aluminium as: Special, at least 99.5 per cent. pure, for aircraft production and electrical apparatus; No. 1, at least 99 per cent. pure, for the general trade; No. 2,

[1] *Chem. Met. Eng.*, Jan. 12, 1921.

98 per cent. pure; No. 3, at least 94 per cent. pure, for use in iron and steel; remelted No. 1, at least 98 per cent. pure, the impurities may be chiefly copper, iron and silicon; remelted No. 2, at least 94 per cent. pure, with not over 0.5 per cent. zinc, and the remainder may be chiefly copper; remelted No. 3, at least 90 per cent. pure, with not over 0.5 per cent. zinc, and the remainder may be chiefly copper; remelted No. 4, at least 90 per cent. pure, with not over 4 per cent. zinc, and the remainder may be chiefly copper.

Soldering.—Al-Solder is an alloy applied to the metal at 250–300° C., and which is stated to melt onto the aluminium, forming an alloy and generating heat. It is hygroscopic and must be kept in an air-tight container. Its composition is kept secret.

Welding.—In autogenous welding, a Swiss patent to the A. G. für Autogene Aluminium Schweissung of Zurich specifies for acetylene welding a flux consisting of a mixture of 60KCl, 12NaCl, and $4K_2SO_4$; when using coal gas or hydrogen flame, more K_2SO_4 is used and some fluorine compounds added. The Griesheim Elektron of Frankfurt used as flux 4KCl, 3NaCl, 1LiCl, 1KBr, and 1NaF, which mixture melts at about 600° C.[1]

Coating.—Prof. Bauer coats aluminium articles with a mixture of 1000 gm. of water, 25 gm. Na_2CO_3, 10 gm. K_2CrO_4, and heats for several hours at 90° C., obtaining a coating said to protect it against salt water and alkalies.[2]

Aluminium-copper Alloys.—R. J. Anderson publishes[1] directions for making rich aluminium-copper alloys, for use in adding copper to aluminium. The alloys concerned are 0.33Cu–0.67Al, 0.50Cu–0.50Al, and 0.60Cu–0.40Al. The best way to make them is to melt the aluminium and copper separately and pour the copper into the aluminium. As much as a ton of alloy can thus be made at a time. Considerable heat is generated by the alloying; in order to avoid the alloy getting too hot, half the aluminium may be melted, and then the other half thrown in as cold bars; the bars float around in the melted bath, and then the copper is poured in. The melting of the floating bars puts a check on the rise of temperature. From the temperature data given by Mr. Anderson, the writer has calculated the following heats of formation of the alloys:

Parts Copper.	Parts Aluminium.	Formula.	Heat of Combination.	
			Per Kg. of Alloy.	Per Formula Weight.
0.33	0.67	$CuAl_5$	35 Cal.	6067 Cal.
0.50	0.50	$CuAl_{3.33}$	49 Cal.	6261 Cal.
0.60	0.40	$CuAl_{1.67}$	67 Cal.	7114 Cal.

[1] *Die Metallbörse.* [2] *Die Metallbörse.*

Duralumin.—Great advances have been made in the manufacture and use of this alloy. The Fokker all-metal airplanes have sheet duralumin wing-coverings replacing fabric, as well as duralumin frame-work, tubing, etc. A number of other similar alloys, cold-worked and heat-treated, are being made for various uses, with tensile strength running 50,000 to 65,000 lb. per sq. in., and their permanent use on a large scale appears assured.

Bauxite

By T. Poole Maynard

Bauxite is a hydrated oxide of alumina of variable physical and chemical composition. It always carries certain impurities, such as silica, in the form of free silica, combined silica and colloidal silica. Iron is usually present as an oxide or a carbonate, and titanium is present in the combined form or free.

The fact that bauxite is a secondary mineral accounts for the great variation in its content of alumina and associated impurities.

Deposits have not been considered of commercial interest unless the bauxite carries as much as 52 per cent. alumina; however, during the past few years, some deposits have been worked which have not carried more than an average of 45 per cent. alumina. These ores have been used in the manufacture of alum.

Ore high in iron content is not desirable for use in the manufacture of alum, although it is a desirable ore for abrasive manufacture. Practically all of the users of bauxite desire ore as low in silica as possible.

United States

Bauxite is mined commercially in Arkansas, Georgia, Alabama, Tennessee and Missouri.

Arkansas.—Arkansas produces 90 per cent. of the bauxite mined in the United States. The ore produced in 1920 amounted to 481,279 tons. During 1919, practically all the bauxite used in the manufacture of alumina came from Arkansas; 28,981 tons of the Arkansas ore was used by the chemical industries and 31,180 tons was used by the abrasive industries, while 1059 tons went into the manufacture of refractories.

The operating companies in the Arkansas field are the American Bauxite Co., the Republic Mining & Mfg. Co., the Globe Bauxite Co., and the E. I. Dupont de Nemours Co., and several smaller independent companies. Arkansas ores are derived from syenites by alteration and metasomatic replacement of the silica by the alumina.

Georgia.—There was a considerable increase in the production of bauxite in Georgia in 1920. Most of the Georgia bauxite is used in the chemical industries, on account of its low content of iron, which is

characteristic of most of the ore. The Georgia production comes largely from the coastal plain area of the State in the area traversed by the Central of Georgia Railway. A new field in southwest Georgia, near Cuthbert, was opened up and considerable ore was shipped to the chemical industries.

The Georgia deposits, particularly in the area traversed by the Central of Georgia Railway, occupy one of the most promising fields for development, on account of the tremendous tonnage of low-grade ores susceptible to concentration by the Everhart process, patents for which have been applied for. The South Georgia bauxites are particularly desirable for the manufacture of high-grade refractories.

Alabama and Tennessee.—The Alabama and Tennessee bauxites are similar in their nature of occurrence and origin, being found associated with the clays which lie unconformable to the Knox dolomite of Cambro-Ordovician age.

The Alabama deposits extend from the vicinity of Piedmont, trending in a general northeast direction to Cave Springs, Ga. These deposits cross northwest Georgia and extend into Tennessee. They are developed in the vicinity of Chattanooga and again in Carter County, Tenn., near the Virginia-Tennessee line.

PRODUCTION OF BAUXITE IN THE UNITED STATES BY STATES
(In tons of 2240 lb.)

State	1912. (a)	1913. (a)	1914. (a)	1915. (a)	1916. (a)	1917. (a)	1918. (a)	1919. (a)	1920. (a)
Alabama....	19,587	27,409	18,547	25,008	46,410	62,134	42,829	43,076	40,029
Georgia.....	14,173								
Tennessee.	126, 105	182,832	200,771	272,033	378,949	506,556	562,892	333,490	481,279
Arkansas..									
Total.....	159,865	210,241	219,318	297,041	425,359	568,690	605,721	376,566	521,308

(a) Statistics of the U. S. Geol. Surv.

UNITED STATES PRODUCTION OF BAUXITE IN 1920

According to figures collected by the United States Geological Survey, 521,308 long tons of bauxite, valued at $3,247,345, was produced in 1920 as compared with 376,566 long tons, valued at $2,201,747, in 1919.

The mines in Saline and Pulaski counties, Ark., produced 481,279 long tons, or 92 per cent. of the total output in 1920. The production from these mines in 1919 was 333,490 long tons.

Georgia ranked second, Alabama third, and Tennessee fourth in production, and the combined output of these three States was 40,029 long tons in 1920, as compared with 43,076 long tons in 1919. In Georgia the bauxite-producing counties, arranged in order of quantity produced, were Sumter, Wilkinson, Floyd, Randolph, Meriwether, Macon, and

Bartow. A number of the mines in Bartow and Wilkinson counties that were worked in former years have been abandoned, but new deposits in Randolph County were opened in 1920.

The bauxite imported in 1920, most of it from South America and France, amounted to 42,895 long tons, as compared with 6,082 long tons in 1919.

CONSUMPTION OF BAUXITE IN THE UNITED STATES (a)

Year.	Production.			Imports.		Consumption.	
	Long Tons.	Value.	Per Ton.	Long Tons.	Value.	Long Tons.	Value.
1909....	129,101	$679,447	$5.27	18,689	$83,956	147,789	$163,403
1910....	149,679	778,203	5.33	15,720	65,743	164,601	782,001
1911....	155,618	750,649	4.87	43,222	164,301	198,840	914,950
1912....	160,124	900,620	5.00	26,214	95,431	186,079	864,363
1913....	210,241	997,698	4.75	21,456	85,746	231,697	1,083,444
1914....	219,318	1,069,194	4.87	24,844	96,500	238,788	925,610
1915....	297,041	1,514,834	5.10	3,420	17,107	284,379	814,755
1916....	425,100	2,296,400	5.40	30	87	407,191	1,309,033
1917....	568,690	3,116,421	5.48	7,691	28,989	554,590	1,824,121
1918....	605,721	3,447,992	5.69	3,653	14,791	589,663	1,939,095
1919....	376,566	2,201,747	5.85	6,082	36,820	364,947	866,473
1920....	521,308	3,247,345	6.23	42,895	408,485	541,946	1,812,234

(a) Statistics of the U. S. Geol. Surv.

Uses

Bauxite has a wide variety of uses. The aluminium industry is the largest consumer, while a large tonnage goes into the chemical industries, more particularly for the manufacture of alum. The abrasive industry has expanded rapidly on account of the growth of the manufacture of alloys of steel and the high-grade abrasives are made largely from bauxite. Some bauxite has been used in the manufacture of explosives, and there is a large field for their application in the production of refractories. It is recognized that super-refractories can only be made from high-alumina materials for commercial use in the chemical industries.

The average value of bauxites in 1920, at the mines, was $8 to $12 per gross ton, depending on the grade of the ore. The average value as shown in the U. S. Geological Survey reports is much less than this figure on account of the basis of valuation of the ore by the largest producer.

Bauxite in Foreign Countries

British Guiana.—The exportation of bauxite from British Guiana in 1920 amounted to 29,399 tons. This was a large increase over the production of 1919, when only 1967 tons was produced. It is reported that several millions have recently been spent by the subsidiaries of the large aluminium interests, namely the Demerara Bauxite Co., Ltd.; in 1919, there was constructed a large crushing and drying plant. Ore-docks have been constructed at the town of MacKenzie, opposite Wismar, at the head of navigation for ocean-going vessels. Ten miles of standard-

gauge railway have been built from MacKenzie at the east bank of the river to the bauxite deposits.

Owing to the lack of demand in the United States the Demerara Bauxite Co. suspended all operations about Jan. 25, 1921, thus throwing many American technical men and native laborers out of employment. This has caused a serious situation in British Guiana, which will doubtless be greatly aggravated by the close of operations of an American company. The output of both concerns has been shipped entirely to the United States. During January, 1921, three cargoes, aggregating 8260 tons, valued at $43,169, were shipped.

The Adriatic Deposits.—Istria and Dalmatia furnished the bauxites for the Central Powers during the war. Most of the deposits were worked by the Austro-Hungarian Government, under military control. These deposits are located in close proximity to seaboard. During 1917, there was a total production of 1,631,222 quintals.

Dutch Guiana.—A law now stands providing the conditions under which the exportation of bauxites from the colony may be undertaken. Preparations to mine and export bauxite are going forward rapidly. During 1919, there was exported from Paramaribo for shipment to the United States 1500 tons of bauxite.

France.—The production of bauxite in France in 1920 was 186,693 metric tons, against 163,447 tons in 1919. There has been a large increase in production and exportation of French bauxites during 1921. The low rate of exchange and the low freight-rates from France to points in this country operated in favor of the development of French bauxite during the past year, and a very large tonnage has replaced the American bauxites. These ores have been placed at the eastern seaboard points in this country at a lower cost than the freight-rate from points in Arkansas and Georgia to points of consumption for the chemical industries. There has, however, been the usual production of American bauxite for aluminium manufacture.

Other Countries.—Bauxite is found in India, West Africa, Spain, Great Britain and elsewhere.

WORLD'S PRODUCTION OF BAUXITE, IN LONG TONS

Country.	1916.	1917.	1918.	1919.	1920.
United States	425,100	568,690	605,721	376,566	521,308
France	104,493	118,973	(a)	160,865	186,693
United Kingdom	10,329	14,724	9,589	9,221	(a)
Italy	8,739	7,666	7,676	2,924	37,360
India	750	1,363	1,192	1,682	(a)
British Guiana	.....	2,790	4,199	1,967	29,399
Spain	.....	.....	453	1,751	.....
Total	549,411	714,206	.....	554,976	.....

(a) Statistics not available.

Aluminium Salts

According to figures collected by the United States Geological Survey, 229 888 short tons of aluminium sulphate, valued at $8,104,457, was produced in the United States in 1920, as compared with 200,034 short tons, valued at $6,763,063, in 1919. Besides the aluminuim sulphate made for sale, 4115 short tons of aluminium sulphate was made and consumed in 1920 by municipal water works, as compared with 4725 short tons in 1919. In 1920 there was also produced 16,824 short tons of alum, valued at $992,259, as compared with 17,019 short tons, valued at $879,198, in 1919.

Data collected relative to use of aluminium sulphate at twenty-two of the water-purification plants in Illinois during 1920 show that 2300 tons of alum was used, ranging from 5 tons at some of the smaller plants to about 780 tons at the largest plant. The cost ranged from $24 to $160 a ton. Analyses made at some of the plants show Al_2O_3, 17 to 17.25 per cent.; insoluble matter, 0.1 to 0.2 per cent.; Fe, 0.5 to 0.75 per cent. In some instances the alum is purchased without specifications, and in others the specifications vary considerably. The alum has been purchased from four different companies.[1]

UNITED STATES PRODUCTION AND IMPORTS OF ALUMINIUM SALTS
(In short tons)

Years.	Production.						Imports. (a)	
	Alum.			Aluminium Sulphate.			Quantity.	Value.
	Quantity.	Value.	Per ton.	Quantity.	Value.	Per ton.		
1912	9,246	$293,995	$31.80	150,427	$2,909,495	19.34	3,342	84,606
1913	9,605	312,822	32.57	157,749	2,977,708	18.88	2,702	66,549
1914	18,238	565,989	31.03	164,954	2,942,572	17.84	2,891	73,028
1915	24,915	699,256	28.07	169,153	3,224,495	19.06	1,408	34,320
1916	27,257	1,177,881	43.21	153,860	4,410,741	28.67	1,247	68,660
1917	19,714	1,017,083	51.60	178,738	5,746,472	32.15	507	39,088
1918	20,286	1,051,449	51.83	209,079	6,473,086	30.96	231	18,519
1919	17,019	879,198	51.66	200,034	6,763,063	33.80	343	21,877
1920	16,824	992,259	58.98	229,888	8,104,457	35.30	.....	.....

(a) Includes alumina, aluminium hydrate, or refined bauxite, alum, alum cake, aluminium sulphate, aluminous cake, and alum in crystals or ground.

[1] *Chem. Met. Eng.*, May 11, 1921.

ANTIMONY

By K. C. Li

During 1920 there were no unusual or remarkable developments in antimony except that its prominence as a "war metal" was still further emphasized and for this reason it suffered perhaps more from the post-war depression than any other metal, unless we except copper. Production of ore in the United States had ceased entirely with the ending of the war, and stocks of metal were so heavy, with such limited demand, especially during the last half of the year, that imports from China were more than sufficient to supply the market and metal in bonded warehouses increased 600 tons during the year. China was the only country able to maintain a large production at the lowered prices resulting and its offerings completely dominated the situation.

No such violent price movements occurred as in the years 1914 to 1917, but a steady decline took place from March to the close of the year.

The Market in 1920

The buying movement which had advanced prices in December, 1919, continued over the beginning of 1920, and from an opening price of 9.75 cts. there was a steady advance to 11.625 cts. in February. This was maintained well into March, when increased imports began to have their effect, and a decline began which continued without halt until the close of the year. March closed at 10.50 cts. and financial disturbances in Japan aided, during April, a further fall to 10 cts. Very light demand in May with slightly increased imports brought prices down to 8⅞ cts. and June, with small sales and heavy drop in silver quotations, saw the market close at 7½ cts., practically at the 5-year pre-war average, 7.43 cts. Imports increased during July and demand was lacking. The price fell to 7.25 cts. and continued declining during August to 7 cts. for the same reasons. During September imports were lighter and a steady market resulted, but the large tonnages of war scrap material, principally shrapnel bullets, sold by both our own and European governments, were too much for the metal to stand and the market showed the effects of these offerings during October, the month closing at 6.375 cts., with demand practically at a standstill. Weakness continued during November and December, the former month closing at 5.75 cts., the final price of the year being 5.20 cts.

Liquidation for inventory purposes and almost entire lack of consumptive demand thus resulted in a closing price 30 per cent. below the pre-war average price, only just over 50 per cent. of the opening price of

the year, and but 45 per cent. of the year's high. It is interesting to note that antimony suffered far more in price than the other non-ferrous metals. Compared with the 5-year pre-war averages, at the close of 1920 copper was approximately 10 per cent. and tin 11 per cent. lower, zinc unchanged, lead 7 per cent. higher and silver 15 per cent. higher.

The close relation, however, between antimony and silver is shown by the fact that silver opened 1920 at $1.30½ per oz. and closed at $0.64½—49½ per cent. of the opening price. Also the high price for silver during the year was $1.37, the low $0.59¼, a total decline of 57 per cent. Antimony from its high price of 11.625 cts. fell to 5.20 cts., a decline of 55 per cent.

The Effect of Silver on Antimony Price

The student of antimony, with these figures before him and a knowledge of conditions in China surrounding the production of antimony, sees readily that, more than the actual cost of production or the consumptive demand, fluctuations in the value of silver cause the price of antimony to vary. Chinese exchange rises and falls with the price of silver. The Chinese miners and smelters sell their metal abroad, receiving pay for their product in gold and paying for labor and materials

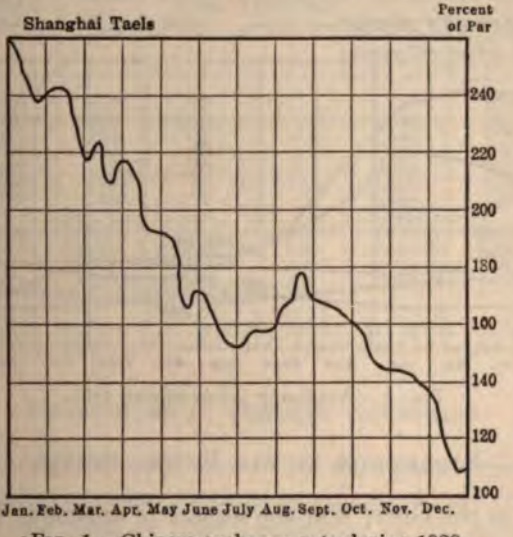

Fig. 1.—Chinese exchange rate during 1920.

in silver. During 1920 the exchange value of the Shanghai tael fell almost 60 per cent. In February silver sold as high as 90d. in London and the tael exchanged for about $1.67. By May the tael had fallen to $1.11 and in December to 70 cts. The relation between these figures and antimony prices for the corresponding periods is very significant.

The fall in price during 1920 was not due to reduction in price by the Chinese miners o rsmelters in Chinese money, but chiefly due to exchange, the course of which is indicated by the sketch.

An important point to recall is also that the lowest price of antimony regulus c. i. f. London was £22 in 1914. At the then rate of exchange £1 was equivalent to 7.5 taels. Thus 1 ton of antimony exchanged for 165 taels, c. i. f. London to the Chinese smelter, or say 155 taels, c. i. f. Shanghai. Today the smelter receives about 125 taels f. o. b. Shanghai.

AVERAGE MONTHLY PRICES OF ANTIMONY (a)
(In cents per pound)

	1916.	1917.	1918.	1919.	1920.
January	42.45	17.29	14.28	7.43	10.58
February	44.31	29.80	13.82	7.17	11.59
March	44.75	32.89	13.09	6.80	11.06
April	42.06	34.04	12.54	6.79	10.50
May	31.60	25.20	12.85	7.66	9.66
June	20.05	19.51	13.06	8.44	8.29
July	14.70	15.83	13.20	8.99	7.50
August	11.53	15.06	14.00	8.96	7.18
September	11.81	14.94	14.15	8.63	7.11
October	12.70	14.75	13.32	8.71	6.72
November	13.84	13.91	8.77	9.11	6.11
December	14.59	15.06	7.92	9.62	5.53
Year	25.37	20.69	12.58	8.19	8.49

(a) *Eng. Min. Jour.* quotations, ordinaries.

As conditions are today any improvement in demand should immediately create a stronger market.

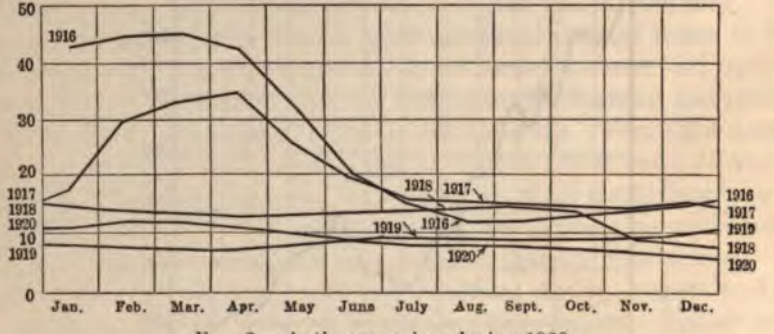

FIG. 2.—Antimony prices during 1920.

PRODUCTION IN THE UNITED STATES

At the end of the Great War the mining of antimony in this country practically ceased and is not likely to be resumed in the near future owing to the high price for the metal necessary to make domestic mining profitable. It has been estimated that a price of 16 to 17 cts. would be necessary over a considerable period of time to stimulate production of ore, but it is probably quite safe to say no mining will be done unless the price should remain at 10 cts. or over. It is quite possible that tariff legislation

during 1921 may result in increasing the present import duty of 10 per cent. ad valorem, but it is not probable that the increase will be other than for revenue-producing purposes or sufficiently great to increase the price in the American market to a figure that will make domestic ores profitable. Foreign countries, especially China, have demonstrated their ability to produce the metal at very low cost and will undoubtedly continue to dominate the antimony market.

ANTIMONY ORE PRODUCED IN THE UNITED STATES (a)
(In short tons)

Year	Ore.	Metal Content.
1915	5000	2100
1916	4500	1770
1917	1000	390
1918	190	50
1919	*Nil*	*Nil*
1920	*Nil*	*Nil*

(a) U. S. Geol. Surv. Production negligible prior to 1915.

ANTIMONY STATISTICS OF THE UNITED STATES
(In tons of 2000 lb.)

Year.	Imports, Antimony Content.			Production. (a)			
					In Hard Lead.		
	Metal or Regulus.	Crude and Ore.	Type Metal.	From Domestic Ore.	From Domestic Ore.	From Imported Ore.	Recovered from Old Alloys, Scrap, Dross, etc.
1909	4,826	1,693	1,327	.....	1,617	743	1,556
1910	4,950	*Nil.*	1,109	.....	1,598	631	2,779
1911	5,479	*Nil.*	727	.....	1,543	711	2,369
1912	6,969	*Nil.*	52	.....	1,224	725	2,506
1913	7,667	25	50	.....	2,204	304	2,705
1914	6,535	993	94	.....	2,518	175	2,646
1915	8,742	1,682	172	.....	2,961	464	3,102
1916	9,875	(b)4,742	119	.....	3,496(d)	.....	4,480
1917	17,825	(b)5,960	*Nil.*	258	2,759(d)	2,182(c)	4,961
1918	13,874	(b)1,360	19	127	2,566(d)	2,490(c)	5,226
1919	7,125	(b)364	1,197	*Nil*	1,943(d)	.....	4,399
1920	12,474	(b)682	2,063	*Nil*	2,033(d)	.....	5,600

(a) Metallic antimony; figures of U. S. Geological Survey; 1919 figures from *Metal Statistics*. (b) in ore only. (c) Antimony metal. (d) Includes both domestic and foreign ore.

Production in Foreign Countries

China.—Although severely affected by the steady decline in the price of antimony in the American markets to a figure 30 per cent. below pre-war average at the close of 1920, production of the metal in China is still on a much larger scale than that of any other country and Chinese imports into the United States are continuing at the average rate of over 500 tons per month, with no arrivals from other countries. Production figures for 1920 are not available, but the output was greatly reduced as compared with the immediately preceding years when the war demand existed. As before, probably over 90 per cent. of the production came

from the Province of Hunan, special attention being given to the development of the Si Kwan Shan district, whose rich and easily mined orebodies permitted production to continue in the face of steadily falling ore prices. The decline in the price of silver was of great assistance in reducing costs to the Chinese producers and was by far the most important factor contributing to the lower price of antimony.

Exports of antimony from China were 1352 metric tons of ore and 14,282 tons of metal in 1920, compared with 580 tons of ore and 8343 tons of metal in 1919.

Stocks of metal were greatly reduced during the year and at one time became so low as to cause doubt in the minds of American buyers as to future supplies. As this was coincident, however, with the heavy decline in silver, bringing renewed production and continued heavy exports, the price of the metal was not affected favorably to the Chinese producer. Under the unfavorable conditions existing and the difficulty of financing either mine developments or smelting improvements, little has been accomplished in either direction in 1920 and much remains to be done. It is unlikely, however, that China will lose her supremacy in antimony for many years to come.

France.—This country retains her second position as an antimony producer, since she possesses abundant supplies within the Republic and in her colonial possessions in Africa and Asia. Algeria, which exported 573 long tons of ore in 1913, was credited with 17,372 in 1917 and 2125 in 1919. Indo-China exported 2208 tons to France in 1917, but figures are not available for later years.

ANTIMONY PRODUCTION IN FRANCE (a)
(In metric tons)

Year.	Mine Production.		Smelter Production.	
	Ore.	Metal Content.	Regulus.	Oxide.
1913	20,872	6,467	3,394	2,996
1914	3,416	674	1,545	821
1915	6,353	1,116	2,834	912
1916	19,037	3,038	4,395	1,509
1917	19,453	2,942	4,534	1,485
1918	10,020	1,661	2,056	1,391
1919	4,123	1,230	1,565	483

Mexico.—Antimony is widely distributed in Mexico, but before the war the operating districts were in the States of San Luis Potosi, Sonora, Durango and Oaxaca. The principal producing mines were in the Catorce district of San Luis Potosi. The ore, which was mainly oxide, was largely shipped to the United States. There was but one smelter,

which produced impure antimony, exported to England for refining. Some antimonial lead was also obtained during the process of refining the lead produced from the silver-lead ores smelted in Mexico.

MEXICAN EXPORTS OF ANTIMONY(a)
(In short tons)

Year.	To England. Crude and Regulus.	To United States.	
		Ore.	Metal.
1912	2,943	.....	.....
1913	2,094	.....	.....
1914	1,378	.....	6
1915	.....	520	.....
1916	.....	1,339	.....
1917	.....	1,775	790
1918	.....	1,449	2,660
1919	.....	297	279

(a) *Min. Res. of U. S.*, Part 1, 1919.

Bolivia.—There are no large producing mines in this country, but many mineralized areas carry stibnite and antimony ochre. Before the war the output of ore was insignificant, but war prices stimulated mining and a large production resulted. The fall in prices to below pre-war levels has greatly curtailed the output. The ore shipped was high grade and was marketed principally in England and the United States.

BOLIVIAN EXPORTS OF ANTIMONY
(In metric tons)(a)

Country.	1913.	1914.	1915.	1916.	1917.	1918.	1919.
To England	.....	.....	16,184	17,377	13,887	.....	.....
To France	62	186	.....	1,113	993	.....	.....
To Spain	.....	.....	140	.....	.....	.....	.....
To United States	.....	.....	1,599	4,258	3,460	.....	.....
Total	62	186	17,923	22,748	18,340	6,849	238

(a) *Min. Res. of U. S.*, Part 1, 1918.

Japan.—Very little antimony ore is produced in Japan and her importance in the industry has been entirely due to the purchase of Chinese ores, the Japanese smelting them and refining the crude in Japan. During the war the refined antimony produced was shipped principally to Russia at first, and later to the United States. At present shipments from Japan are very small.

Other Countries.—Many other countries produced antimony during the war period, but in normal times only Italy and Austria-Hungary are of any importance. A table of the world's production of antimony from 1912 to 1919 is given below.

WORLD'S PRODUCTION OF ANTIMONY (a)
(In metric tons)

Country.	1912.	1913.	1914.	1915.	1916.	1917.	1918.	1919.
United States	.....	.....	.....	1,760	1,420	310	45	*Nil*
Canada	.....	.....	.....	381	272	87	.....	40
Mexico	3,500	2,340	1,570	(b)200	829	2,647	3,269	628
Bolivia	40	30	102	9,859	15,077	12,860	4,770	.....
Peru	.....	.....	.....	260	930	450	160	33
Hungary	872	1,038	.....	.....	.....	444	.....	.....
Austria-Hungary	1,160	840	.....	.....	.....	.....	.....	.....
Germany	.....	.....	.....	(b)700	.....	.....	.....	.....
France	1,910	5,170	540	893	2,430	2,354	1,329	976
Italy	310	360	138	720	4,334	960	.....	.....
Spain	170	.....	.....	100	170	160	(b)20	*Nil*
Portugal	50	10	.....	.....	(b)1,000	.....	.....	.....
Serbia	300	(b)250	.....	.....	.....	725	.....	.....
Algeria	1,417	186	320	2,740	8,940	4,550	2,218	605
British South Africa	.....	30	.....	50	380	300	99	32
China	13,530	13,032	19,647	23,357	42,800	31,000	(b)18,112	8,923
Japan	75	20	32	180	280	8	41	.....
India	.....	.....	.....	.....	400	50	*Nil*	.....
Indo-China	.....	.....	.....	160	642	101	.....	.....
Borneo	.....	.....	300	120	.....	.....	.....	.....
Asia Minor	270	240	.....	.....	.....	.....	.....	.....
Victoria	590	960	890	1,300	1,320	.....	576	580
New South Wales	40	10	20	320	310	150	(b)120	(b)30
Queensland	.....	.....	.....	80	80	.....	.....	3
Western Australia	.....	.....	.....	.....	20	10	.....	*Nil*
	24,234	24,516	23,559	43,180	81,634	57,166	30,759	11,850

(a) U. S. Geol. Surv. (b) Incomplete data; actual production probably larger.

TECHNOLOGY

As there has been no further development of antimony mines in the United States since the war and the consumption requirements of the country have been readily satisfied by imports of Chinese metal, no improvements are reported in smelting methods and the writer is referred to the article on antimony in MINERAL INDUSTRY for 1919, Vol. 28, for a brief description of smelting processes. The general depression affecting those industries which are the principal users of antimony has also retarded research into and investigation of improved processes for manufacture and use of antimony products in the rubber, pigment, alloy and other industries using metal, especially since other raw materials employed in those industries and competing with antimony have been selling at below pre-war prices and have been in plentiful supply. Now that antimony and its products have touched such low price-levels a renewed interest is noted in the development of antimony-oxide pigments and also in the use of antimony oxide to replace zinc oxide in the manufacture of rubber tires. In England Cookson & Co. are actively pushing the introduction of a new antimony-oxide pigment which they have placed on the market under the name "Timonox," and in an article read by Herbert E. Clark, before the Oil & Color Chemists Association in January, 1921, the following statements are made.

The early oxides of antimony had a somewhat coarse crystalline structure; moreover, they were not always white—off-color examples varied widely from grayish white to yellow. The writer's study of the pigment has been chiefly directed to that sold under the name of "Timonox," the manufacturers of which send out two grades, one a very pure white, styled "Red Star" and the other a pale ivory, styled "Green Star." The two forms differ slightly chemically.

Both forms of the oxide are of impalpable fineness and show under the microscope a uniform crystalline condition; the particles are smaller than those of white lead, but larger than zinc-oxide particles. "Red Star," oxide is not so fine-particled as "Green Star," and accordingly has lower oil-absorption and hiding power. In average samples 99.8 per cent. can easily be washed through a 300-mesh sieve.

The specific gravity is about 5.4 by ordinary methods, but if precautions are taken (by exposure of the material to a good vacuum) to remove all adhering gas, a value of 5.73 can be obtained. This is quite close to the value for zinc oxide, but the two pigments have little else in common, and may almost be regarded as complementary to one another in practice. Thus antimony oxide is very easily incorporated either with water or oil; smooth uniform pastes in oil can be obtained without the necessity for heavy grinding, and the oil required for a given consistency is nearer to that taken by white lead than by zinc oxide, an average grinding for soft linseed-oil pastes running 10 per cent. oil. By incorporating oil and pigment in an edge-runner mill, the oil content of paste of a given consistency may be reduced, and the paste shows little or no tendency to separate out oil. Ready-mixed paints of good brushing qualities can be made, containing nearly 80 per cent. of pigment. These, with the appropriate vehicle, are suitable for flat finishes, which are readily obtained with antimony oxide. For glossy coats it is well to use mixtures containing 70 per cent. of pigment, or less, and vehicle with three or four parts of oil to one of turpentine. Satisfactory results have been obtained with pale boiled linseed oil, but whatever medium is chosen, it is found that proper attention must be paid to the drying rate of the paint in order to secure permanent gloss, as antimony paint films which are allowed to dry too slowly have a tendency to remain somewhat soft and to turn flat, the gloss which may at first be displayed disappearing in the course of a few days. In order to obtain permanent glossiness it is desirable, when thinning, to use a proportion of liquid cobalt drier (resinate or linoleate or a mixture), adjusted to the special circumstances, but averaging for the usual drier supplied to the trade (which contains say 1 per cent. cobalt oxide) a quantity equal to 2 per cent. by weight of the mixed paint.

Antimony oxide has no accelerating action on the drying of linseed oil; films dry in the same time, or in slightly longer time, than the oil alone. It is accordingly the practice in manufacturing antimony-oxide paste in refined linseed oil to add litharge equivalent to 0.5–1.0 per cent. of the weight of dry antimony pigment, and zinc oxide equivalent to 1.0–5.0 per cent. of the same. These substances are first thoroughly ground in oil and then incorporated with the main bulk of the pigment and oil in an edge-runner mill. Instead of litharge, or as part substitute for it, basic sulphate or basic carbonate of lead may be used, the amount being calculated from the proportion of the basic PbO present, *i.e.*, the proportion over and above that required for $PbSO_4$ or $PbCO_3$; or equal parts (say 0.5 per cent. each) of litharge and manganese borate may be used, or gold size may be added to the grinding oil. The zinc oxide has been found to improve the keeping qualities of the paint after mixing, especially antimony-oxide paint, reduced with barytes, to which further reference will be made later. It also neutralizes the tendency towards softness of film, which is sometimes shown by pure antimony-oxide paint.

Pastes made with such additions as are indicated above closely resemble white-lead paste of high quality. They become covered in a few days with a protective skin, and keep in good condition with the surface exposed to air or covered with oil or water. They are broken down very easily by the regular paint vehicles, yielding paints with excellent brushing qualities, purity of color and great opacity. Tests under practical working conditions have shown that "Timonox" antimony oxides may be ground with their own mass of barytes and still give paints not measurably inferior in spreading and hiding properties to genuine white-lead paint. Any satisfactory white-lead subsitute must be free from the special objection raised against the latter, *i.e.*, that it is dangerous to the health of workmen employed in its manufacture and use.

The properties of antimony oxide seem to assure for it an honorable place among the white pigments, apart from mere questions of possible competition in price, but the author is of the opinion that antimony oxide reduced with as much as its mass of barium sulphate is likely to receive wide adoption as a cheap and efficient pigment in the immediate future. This opinion is based on results achieved with reduced antimonial paints and enamels, where zinc oxide in relatively small quantities has been added as an auxiliary. Pure antimony-oxide paints do not chalk or craze, while outside exposures made on iron and wood nearly three years ago show that this pigment may be heavily reduced with barytes and yet give paints of remarkable wearing power . . .

The thickening of varnishes by polymerization or other changes is apparently provoked by basic pigments, especially in very acid varnishes and those made from China wood oil. Antimony oxide has here a wide field of usefulness; it is inert to China wood oil, rosin varnish, and in enamel manufacture admits of zinc oxide being added in fair proportions without serious thickening of the varnish. Thus in a series of tests linseed-oil pastes made from (1) zinc oxide 25 per cent. with antimony oxide 75 per cent., and (2) zinc oxide 50 per cent. with antimony oxide 50 per cent. were thinned with such a varnish (acid figure 28) until the mixture contained 60 per cent. pigment. Thickening was inappreciable in (1), while in (2) thickening occurred within the first 24 hours, which could be corrected by the addition of one part of turpentine to eight parts of enamel. This thinned-out mixture showed no further tendency to change in consistency and had all the hardness and brilliance of the original enamel on application.

Dr. C. T. U. Bahst, L. R. C. P., L. R. C. S., who has a long and intimate experience as appointed surgeon to works manufacturing lead and antimony and their compounds, wrote: "I have had under my observation for many years the workers in Messrs. Cookson & Co.'s antimony works, who have been continually exposed to antimony fumes, containing the oxide of metal. These men have never shown any symptom of poisoning." Men who have been exposed to fumes of antimony oxide over a period of 50 years, and even more, have suffered no internal harmful effects. Occasionally, cases of local skin eruption on the hands, forearms, etc., have been observed. These sores are temporary and always disappear in a few days. They can practically invariably be traced to local irritation, or to slight cuts or contusions, and arise when the skin is freely perspiring.

In conclusion, it may be observed that for paint and enamel purposes antimony oxide is not to be regarded as absolutely independent of other pigments. It derives, for example, great help from zinc oxide, and opens a new and important chapter in the technology of mixed pigments. Its mission is not solely to displace or replace, but to co-operate with existing pigments for the creation of products of new application and increased value in protection and decoration.

In this country certain of the rubber-tire manufacturers are reported to be conducting experiments in the use of antimony oxide as a substitute for zinc oxide with very satisfactory results both as to quality and cost of product and service results obtained. As antimony oxide is now available at about the same price as zinc oxide and as the greatly increased productive capacity of China is available to furnish supplies of antimony oxide at low prices, it would appear that a new field for antimony may soon be developed which would greatly benefit and tend to stabilize an industry which has been subject to extremes of depression and over-stimulation with resulting unsettlement of markets.

The conditions described under markets and production have adversely affected any improvement in the technology of the metal in other countries, and no new developments are reported.

Uses and Consumption

The peace uses of antimony, although many, do not require large quantities of the metal and even under the stimulation of war demand the production did not exceed a reported figure of 82,000 metric tons a year. Consumption of the metal, however, as indicated by production, imports into consuming countries, and stocks, including the very heavy supplies of war-scrap, including shrapnel bullets—which have supplied a large tonnage of antimony during the last two years—would appear to be steadily increasing, and apparently the field of usefulness of antimony is widening. Unalloyed metallic antimony is used, in the form of a fine powder, "Iron-Black," to give a polished steel-like appearance to articles made of papier-mâché or pottery. It is produced by precipitation from an acid solution of antimony salts by metallic zinc. By far the principal use of antimony is to alloy with other metals producing babbitt and other bearing metals, hard lead, white-metal (soft-metal) alloys, type-metal, battery-plates, Britannia metal, etc. During the war year of 1917, approximately 73 per cent. of the antimony consumed in the United States was used as above, while only 7 per cent. went into shrapnel.[1]

White antimony oxide is used for making opaque white enamel and other sanitary ware, successfully replacing tin oxide. It is also used as a coloring agent in glass manufacture. A use daily growing more important is for paint pigments. Red sulphides of antimony are used for galvanizing and as coloring matter for red rubber, also as paint pigments. Stibnite, or crude antimony sulphide, is used in the manufacture of safety matches. Antimonate of lead, containing an excess of lead oxide, known as "Naples yellow," is used in oil paints, glass and pottery. Tartar emetic and antimony fluoride are used in dyeing, as mordants.

[1] Census of War Commodities, Department of Commerce.

Tartar emetic and antimony oxide are also used medicinally. Antimony sulphide is used as primers in shells, in cartridges and also, as a powder, in the charges of some shells to produce on explosion a dense white smoke, which facilitates range finding. During the war an important use of antimony was for shrapnel-bullets, which were made of antimonial lead, containing 12 to 13 per cent. antimony. The return to the market of unused bullets has had a serious effect during the past two years on the consumption and price of both virgin antimony and lead.

The total consumption of antimony has never been large enough to remove it from the list of the minor metals, and before the war the average annual world consumption was estimated at 20,000 metric tons. During the war the world production was reported to average over 60,000 metric tons yearly for 1915 to 1917 and it seems almost certain that new uses will be developed for the metal, in view of the demonstrated possibilities as to tonnage, production and the low cost at which present supplies are being won. As mentioned earlier in this article evidences are not wanting that consumption is even at present on a scale exceeding pre-war demand.

ARSENIC

By A. E. Wells

Uses of Arsenical Compounds.—The form in which arsenic is generally marketed is the white arsenious oxide (As_2O_3), as the uses of arsenic usually demand its industrial application in this form. Chief among the uses of white arsenic is the manufacture of insecticides and sprays, the commonly known of which are Paris green and lead arsenate. Glass-making also consumes a large amount of arsenic, which imparts an increased brilliancy to the glass. Crude commercial white arsenic is often used to kill weeds along railroad tracks. Arsenious oxide is used also for preserving hides, while the disulphide (As_2S_3), is used for dehairing hides for the finest-grade leather, as it least affects the product.

Sodium arsenite is the principal poisonous ingredient of many cattle- or sheep-dips. Arsenic compounds are also used medicinally.

Calcium-arsenate insecticide has been shown in the experiments of the United States Department of Agriculture to have an effectiveness probably equal to that of lead arsenate, and an important saving is effected by the substitution of cheap lime for the more expensive lead oxide.

Uses of Metallic Arsenic.—Metallic arsenic is used as a flux for promoting the union of metals which otherwise would be difficult to mix. The trioxide cannot be successfully substituted for the metallic arsenic in this work. Arsenic bronze, now used for railroad brasses, is a good example. Its composition is: copper 80, tin 10, lead 10, arsenic 8. The structure remains unchanged, but there is a gain in crushing strength and a lower temperature is required to crystallize. A content of 0.65 metallic arsenic increases the resistance to hammering.

Market.—The demand for white arsenic in 1920 was even greater than in 1919, when 12,000 tons was consumed in this country. The increase has been due to increased requirement of the mineral for the making of insecticides. Production in the United States was entirely inadequate to supply the demand, and consequently prices were very high, white arsenic being quoted up to 15 and 16 cts. per lb. during the spring of the year. With the general curtailment of industries and the seasonal slacking-up in demand, the price fell, and during the last several months arsenic sold for 10 and 12 cts. per lb. One company supplied a large contract over the year at less than 10 cts. per lb.

Production.—The domestic production amounted to 11,502 short tons, nearly double the 1919 output.

The principal producers are the American Smelting & Refining Co., from the Globe plant, at Denver, and the plant at Tacoma, Wash.; the United States Smelting Co., at Midvale, Utah; and the Anaconda Copper Mining Co., at Anaconda, Mont. The arsenic from the above-named plants was produced primarily as a by-product from lead- and copper-smelting operations. Because of the high prices and heavy demand, the first two companies made special efforts to obtain high-arsenical ores and to smelt as large a percentage of these as possible with their regular furnace charges. The Globe plant of the American Smelting & Refining Co. treats the high-arsenical dust and fume obtained in the bag-houses and Cottrell apparatus at several of the other Western plants of that company. The United States Smelting Co. has begun to produce calcium arsenite at Midvale, Utah, and is experimenting with the production of other arsenical products. The production at Anaconda gradually increased during 1920, and in the future the Anaconda production should be an important factor in the market. When running at normal smelting rate, the Anaconda plant has a potentially large arsenic-productive capacity, but the probabilities are that with the great increase in the demand for that material, there will be no serious over-production.

Tariff.—Arsenious acid and arsenic acid are now on the free list. Congress has been requested to place a duty of 5 cts. per lb. on these articles and a proportionate rate on the arsenic content of Paris green and London purple, in the interest of the domestic arsenic industry. An ad valorem duty of 20 per cent. is asked for other arsenical compounds.

STATISTICS OF ARSENIC IN THE UNITED STATES (a)
(Short Tons)

Year.	White Arsenic.							Sulphide of Arsenic.		
	Production.		Imports.		Supply.			Imports.		
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Per Ton.	Tons.	Value.	Per Ton.
1906	737	$63,460	167	$13,436	904	$76,896	$85.07	3,820	$336,609	$88.12
1907	1,751	163,000	203	21,558	1,954	184,558	94.47	4,961	553,440	88.61
1908	1,302	99,193	168	13,263	1,470	112,456	76.46	4,796	417,137	86.97
1909	1,214	52,946	444	31,235	1,638	84,181	51.39	3,592	272,493	75.86
1910	1,497	52,305	1,010	62,590	2,507	114,895	45.83	4,128	251,716	60.97
1911	3,132	73,408	1,921	116,948	5,053	190,356	37.68	2,702	159,626	59.04
1912	3,141	190,757	3,103	200,616	6,244	391,373	62.68	3,379	246,815	73.04
1913	2,513	159,236	1,519	133,597	4,032	292,833	72.62	3,344	285,537	85.38
1914	4,670	313,147	1,594	109,121	6,244	422,268	67.42	2,040	165,266	81.03
1915	5,498	302,116	1,400	113,677	6,898	415,793	60.28	1,787	154,517	86.46
1916	5,986	555,187	1,071	107,876	7,057	663,063	93.96	1,090	124,844	114.49
1917	6,151	1,118,313	1,178	264,534	7,329	1,382,847	188.50	2,776	410,341	147.80
1918	6,323	1,213,000	1,847	441,212	8,170	1,654,212	202.47	5,651	998,011	176.61
1919	6,029	1,180,000	4,389	624,494	10,418	1,804,494	174.17	2,151	316,687	147.22
1920	11,502	2,021,356	3,740	532,635	15,242	2,553,991	167.95	4,080	684,016	167.65

(a) Production from U. S. Geol. Surv.; imports from Dept. of Commerce.

WORLD'S PRODUCTION OF ARSENIC
(In metric tons)

Year.	Canada. (a)	Germany. (b)	Italy. (d)	Japan. (a)	Portugal. (d)	Spain. (b)	United Kingdom. (a)	United States. (a)	France. (d)
1905	*Nil.*	2,535	.....	8	1,562	1,140	1,552	701	3,627
1906	*Nil.*	3,052	.....	5	1,322	1,114	1,625	754	6,534
1907	317	2,904	73	7	1,538	2,400	1,523	916	7,900
1908	649	2,822	451	20	1,655	2,004	2,007	1,301	2,381
1909	1,020	2,911	*Nil.*	8	1,420	506	2,911	914	2,141
1910	1,363	3,066	*Nil.*	12	974	444	2,187	1,203	8,045
1911	1,815	2,981	16	6	887	331	2,178	2,800	19,000
1912	1,858	4,869	*Nil.*	.....	1,006	(c)	2,228	2,855	81,880
1913	1,538	5,008	*Nil.*	.....	925	.....	1,723	2,158	70,613
1914	1,576	4,700	*Nil.*	.....	960	.....	2,020	4,238	250
1915	2,174	4,100	*Nil.*	15	.....	.....	2,536	4,990	1,300
1916	1,983	.....	*Nil.*	(c)	.....	.....	2,587	5,430	1,800
1917	(e)2,663	.....	*Nil.*	(c)	.....	.....	2,669	5,580	344
1918	(e)3,233	.....	*Nil.*	398	.....	104	2,387	5,737	728
1919	(e)3,074	.....	*Nil.*	1,299	.....	42	2,568	5,470	2,261
1920	(e)2,184	.....	.....	.....	.....	.....	.....	10,435	523

(a) White arsenic. (b) Oxide, sulphide, etc. (c) Not yet available. (d) Ore. (e) Includes arsenic in ore.

Arsenic in Foreign Countries

Canada.[1]—The demand for arsenic has been particularly strong. The Canadian production includes arsenious oxide refined and crude produced in the smelting of the arsenical silver-cobalt-nickel ores of the Cobalt district; in addition to this arsenic has been recovered at Tacoma, Wash., from the arsenical gold concentrates shipped from the Hedley gold mine at Hedley, B. C.

The total production in 1919 was 2859 short tons of arsenious oxide and approximately 530 tons of arsenic in concentrates, having a total valuation of $509,924. In 1920 the production was approximately 2408 tons of arsenic, including white arsenic and arsenic in concentrates, valued at $313,575.

PRODUCTION AND EXPORTS OF CANADIAN WHITE ARSENIC

Year.	Production. (a)		Exports. (b)	
	Short Tons.	Value.	Short Tons.	Value.
1913	1,692	$101,463	1,303	$107,094
1914	1,737	104,015	1,876	132,567
1915	2,396	147,830	2,318	174,190
1916	2,186	262,340	1,975	197,458
1917	2,936	669,431	4,286	507,898
1918	3,560	563,639	2,672	393,883
1919	3,389	509,924	2,506	355,654
1920	2,408	313,575	1,028	237,267

(a) Includes some arsenic in concentrates. (b) Practically all was exported to the United States.

Japan.[2]—Arsenic is found in Japan as an ore, as well as being a by-product from the smelting of copper and lead. Ore deposits are said to

[1] Can. Dept. of Mines.
[2] Vice Consul H. T. Goodier, Yokohama, *Comm. Rept.*, Oct. 27, 1920.

be fairly large in the Prefectures of Oita, Miyazaki, Hiroshima, Hyogo, Shimane and Okayama, their percentage of arsenic ranging from 15 to 30 per cent.

In 1918, 1,828,198 lb. of ore valued at $9,204 was produced. The output increased to 2,133,281 lb. in 1919, but its value decreased to $6,975. This did not include ore used at the mines by the companies for producing arsenious acid, or crude "arsenic."

Concerning this "acid" available statistics give the total production in 1918 as 877,651 lb. and 2,862,653 lb. in 1919. Its exact value is unobtainable, but may be estimated from the declared export returns of consulates in Japan, excluding Taiwan and Dairen. The total export to the United States in 1919 is given as 1,821,340 lb. with a value of $70,739, of which 1,387,388 lb., valued at $48,337, was from Yokohama. The total export from Yokohama to the United States during the first seven months of 1920 is stated as 1,102,020 lb., valued at $39,510.

Arsenious acid is produced in Japan by direct reduction of arsenic ore and also as a by-product in copper and lead smelting. The former method has been used on a small scale for the last 10 years, but only quite recently have by-product methods been installed by certain copper and lead-mining companies in endeavors to consume poisonous gases, etc., from smelting operations.

Under the direct method of producing arsenious acid one company is said to have a capacity of about 3333 lb. at a firing. The charge is renewed about twenty times a month. From ore of 20 per cent. arsenic the output of one furnace will make approximately 13,333 lb. of crude arsenic each month.

About 20 per cent. is lost in refining.

The three largest manufacturers of arsenious acid in Japan are said to approximate a monthly output of seventy tons (crude only), thirty and fifteen tons (both refined), respectively.

The arsenic content of acid thus produced by both methods is, roughly, 95 per cent. in the crude and about 97 to 99 per cent. in the refined.

If the industry is given adequate support by large companies, it is claimed that 4000 tons of white arsenic per year can be produced from known sources.

As very little white arsenic is used in Japan, only in the preparation of a few medicines, in the manufacture of insecticides on small scale, and occasionally for wall-paper coloring, etc., the greater part of the annual production is available for export—largely to the United States, Great Britain, Australia, and a little to the Philippine Islands.

Mexico.—In 1920, the production of white arsenic from the Mapimi

smelter in Mexico was nearly 250 tons per month. This plant was closed down early in 1921.

Queensland.[1]—With the exception of one or two unavoidable stoppages, the State Arsenic Mine of Jibbinbar, in the Stanthorpe district, worked to its full capacity throughout the year, in the endeavor to meet the keen demand existing for the poison for the destruction of prickly-pear and other purposes. Towards the end of the term a particularly promising face of ore was exposed in the No. 1 level of the mine, which is developing very satisfactorily. The quantity of arsenic produced during the year was 285 tons from 3000 tons of ore for eight months' work, this being a large increase on the yield for the preceding year. The Sundown mine, in the same district, was responsiblefor a further yield of 20 tons of arsenic.

Union of South Africa and Southern Rhodesia.—Previous to the year 1917 there had been no production of arsenic for commercial purposes in South Africa. During 1918, two companies engaged in roasting tin ore erected condensing chambers for the purpose of condensing arsenic. The total production for the Union of South Africa was 15 short tons in 1918, 8 tons in 1919, and 11 tons in 1920. In Southern Rhodesia the output is much larger, amounting to 242 tons in 1919 and 437 tons in 1920.

The Union of South Africa consumes annually about £80,000 worth of sodium arsenite for sheep- and cattle-dips. The value of the total consumption of arsenic compounds is stated to be £100,000, and the question of making the union independent of imports of this commodity has recently received attention.

The Standard Arsenic (S. A.) Ltd. was formed in September, 1919, for the purpose of mining arsenical ore, and the making and selling of arsenical cattle-dips and other compounds, in the Umtali district, Southern Rhodesia. This company is producing about 500 tons of white arsenic per year.

PRODUCTION OF ARSENIC IN THE UNITED KINGDOM

Year.	Arsenical Pyrite.		White Arsenic.	
	Long Tons.	Value.	Long Tons.	Value.
1913	35	£29	1,695	£16,616
1914	.....	.....	1,988	19,052
1915	421	233	2,496	32,779
1916	300	300	2,545	56,104
1917	434	2,599	2,626	146,031
1918	477	4,380	2,349	210,101
1919	75	.....	2,527	.....

United Kingdom.—The arsenic output of Great Britain is obtained mainly from mines in the Camborne-Redruth and Kit Hill-Calstock

[1] *Queens. Govt. Min Jour.*, Apr. 15,1921.

districts, where the tin ores contain an admixture of arsenopyrite. Mines near Calstock, which were formerly worked for copper ores, recently have been worked for arsenical pyrite.[1]

METALLURGY

White Arsenic.—There has been very little development during the last year in the metallurgical processes for the production of white arsenic.

Mr. E. C. Williams[2] conducted experiments to determine the conditions most advantageous for obtaining a dense white product free from antimony and lead. These investigations emphasized the fact that carefully controlled draft regulation and deep cooling chambers are desirable for the production of a satisfactory product when derived from dust carrying lead and antimony.

Metallic Arsenic.—Prior to the war this country imported about 25 tons per year of metallic arsenic. Subsequently the production has been developed in a Chicago plant to meet the present demand in this country. Although the consumption of metallic arsenic is small, the process for the production thereof, as practiced by the Hoskins Process Development Co. at a plant located in the west-side manufacturing district of Chicago, is worthy of mention.[3]

The Hoskins Process Development Co.'s plant consists of a battery of four reduction furnaces having a total capacity of 250 to 300 lb. of metal per day. The charge to these furnaces consists of about 1 lb. of wood charcoal to 4 lb. of arsenic trioxide, thoroughly mixed. The reaction in the furnace between 650 and 700°C. is $2As_2O_3 + 6C = As_4 + 6CO$.

These furnaces are built of large steel pipe surrounded by No. 1 firebrick held in place by riveted steel plates, all supported on pipe framework. The furnaces are heated by gas. The water-cooling supply for the charging end cover is conducted through the smaller pipe. This cover is clamped against a clay gasket in which is buried a ¼-in. copper pipe filled with the cooling water. In case of any leak of the arsenic fume it condenses against the cooled surface, rendering the joint tight.

The period of operation varies between 7 and 10 hr.

Arsenate of Lead.—Under the Luther & Volck patent, No. 892,603, held by the California Sprey Chemical Co., the process for the manufacture of arsenate of lead is carried out by combining lead oxide (litharge) suspended in water and arsenic acid in solution, the reaction being assisted by the action of a catalyzing agent—either acetic acid or nitric acid. The specification gives the formula or combining weights of lead

[1] Imperial Mineral Resources Bureau, London.
[2] *Eng. Min. Jour.*, Oct. 2, 1920.
[3] Chester H. Jones, *Chem. Met. Eng.*, Nov. 17, 1920.

oxide and arsenic acid, respectively, as varying between 1.938 to 2.9 parts of lead oxide to one part of arsenic acid, according to whether ortho-arsenate or pyro-arsenate is desired. The preferable proportion of the catalyzing agent is given as 1 to 3 lb. of the catalyzer to 100 lb. of the lead oxide.

Calcium Arsenate.—The Department of Agriculture, in its laboratory at Tallulah, La., developed the most effective method of controlling the boll weevil yet devised. It was found that the boll weevil relied upon the dew on the plant for its liquid. By dusting the leaves of the cotton plant early in the morning with calcium arsenate, it was discovered that the dew could be poisoned sufficiently to kill a large proportion of the weevils. The discovery of this method of boll-weevil control led to a very rapid expansion in the demand for calcium arsenate.

ASBESTOS[1]

By Oliver Bowles

General.—Asbestos is distinguished from other minerals chiefly by its fibrous structure, and it is this structure that gives it its commercial value. Asbestos may be woven into fabrics or felted into sheets that are incombustible, and thus it is capable of rendering in many industries peculiar services for which no substitute materials may be employed. Mineralogically asbestos falls into various classes such as anthophyllite, chrysotile, crocidolite and amosite. Commercially asbestos falls into two great divisions, the spinning and the non-spinning fiber. Anthophyllite is chiefly non-spinning, while the other three varieties mentioned above have sufficient strength and flexibility for spinning purposes if the fiber is long enough. The spinning fiber may be subdivided into various classes, each depending on its quality and the nature of the product for which it is best adapted. Mixed fibers are commonly used. Chrysotile is generally regarded as the highest grade of spinning fiber, though with improved processes of fiberization and treatment good results are now being obtained from the use of crocidolite (blue asbestos) and amosite. The United States is the largest producer of finished asbestos in the world, but produces only a small proportion of its requirements of raw material, for which it depends to a large extent on the rich deposits of Quebec, Canada.

The chief deposits of the world are in Canada, while other important deposits are found in Russia, South Africa and Arizona. Deposits at present of minor importance, but some of which may develop greatly in the future, occur in Italy, Cyprus, China and Australia.

Asbestos fiber is classed in two groups known as crude fiber and mill stock. The crude fiber, which is graded as No. 1 and No. 2, is the longest material, which is broken from the rock by hand methods and is not passed through the mill. It is the highest grade of spinning fiber. Mill stock is the product obtained after the rock is crushed, passed through beaters and the fiber removed by screening or air separation. It falls into three or more grades according to the fiber length. The better grade of mill stock may be used for spinning purposes.

[1] Published by permission of the Director of the Bureau of Mines.

Uses.—The chief uses of spinning fiber are for the manufacture of fireproof curtains, firemens' clothing and similar fabrics, rope, brakeband linings for automobiles, gaskets and packings. Asbestos fiber mixed with Portland cement is used in the manufacture of roofing shingles, floor-tile, wall-board, fireproof coverings for both wood and metal, fire- resisting cement and similar products. Rubber is used with asbestos in the manufacture of various types of packings. Asbestos cement is widely used for heat insulation on steam and water pipes, in cold-storage plants, and as a lining in safes, stoves and furnaces. Asbestos paper is used extensively in the building industries. In the laboratory asbestos is used for acid-filters, for stoppings in combustion-tubes, for fireproof supports and protectors, and for wicks in producing colored flame by saturation with mineral salts. Asbestos paper and twine soaked in sodium silicate and afterwards treated with calcium-chloride solution are used in the preparation of glass apparatus. There are many hundreds of minor uses distributed among a multitude of industries.

Market Conditions.—During the early part of the year the demand for asbestos was fairly strong, but the general industrial depression which set in during the latter part of 1920 was reflected in the development of little new business, though it actually resulted in few cancellations of orders. The depression in the automobile industry affected asbestos sales most directly, for it resulted in a greatly restricted demand for brakeband linings, which was most acute during the latter part of the year. A peculiarly anomalous situation resulted, for, although the demand fell, and the market was dull, the price remained at its unprecedented high level, December quotations for No. 1 crude running beyond $3000 per ton. The average price of crude fiber imported from Canada was more than $160 per ton higher than the average price for 1919. There seems to be no early prospect of any substantial lowering of the present price-level.

Acute car shortage early in 1920 resulted in stocking up of warehouses and shipment largely of high-grade fiber, with an ensuing shortage of lower grades in the hands of American manufacturers. Twice during the year shipments were made by barges from Quebec via Lake Champlain.

On the whole asbestos suffered less depression than most mining industries, for there was a sustained demand for certain grades of fiber. The increase in building resulted in a fair demand for asbestos shingles, wall-board and similar structural products. Also there was a marked increase in the demand for pipe-covering and other insulation material due to a desire to conserve high-priced fuel.

General Production Situation.—As heretofore, Canada was the chief source of supply, and Canadian production was sustained remarkably well.

While the sales of Canadian crude were somewhat smaller than in 1919, the mill-stock sales increased considerably. There was a marked increase in domestic production in the Arizona field, from 420 tons in 1919 to about 1000 tons in 1920, practically all of which was of spinning grade. The most notable feature of the general foreign situation was the increased development of the South African deposits, the amosite of Transvaal, the crocidolite of Cape Colony, and the chrysotile of Rhodesia.

Advances and Developments.—Some of the more noteworthy events that characterized the industry during 1920 are given below in brief form, and more detailed information concerning some of them is given under the regional descriptions.

An interesting development in asbestos spinning is the production during the year of a number 50 yarn, which means that the yarn runs 5000 lineal yards per pound. Reports indicate that the finest yarn spun heretofore contained only 3000 yd. to the pound.

A new application that may have an important bearing on the utilization of lower grades of mill fiber is the use of short-fiber asbestos with Portland cement for road construction. It is claimed that a mixture of a small proportion of the fiber with cement greatly improves the surface of concrete roads. They resist pitting remarkably well, and the presence of the fiber greatly reduces the rate of enlargement of holes in the road surface. If this type of concrete road proves to have definite advantages as claimed, it will open up a new market for several thousand tons per year of short fiber.

A development which dates back to previous years, but which came into greater prominence in 1920, is the manufacture of asbestos wood as a switchboard material. It is claimed for such products that they have very high dielectric strength, and that they are lighter in weight and less easily broken than other types of switchboards.

A projected renewal of the asbestos industry in Vermont, which at one time was the leading asbestos state in the country, but which has shown no production for a number of years, is a development of interest.

A significant feature of the 1920 situation is the importation from South Africa, directly and indirectly, of over 4500 tons of asbestos. This indicates that United States consumers are not as dependent as formerly on Canadian fiber, though it must be remembered that for certain important uses no fiber yet found can properly take the place of Canadian crude.

Imports and Exports of Asbestos.—As a very large proportion of the United States requirements are imported, the various sources from which imports are obtained may be of interest to the consumer. The following

table compiled by Edward Sampson of the U. S. Geological Survey shows the imports in short tons over a series of years.

UNITED STATES IMPORTS OF ASBESTOS
(In short tons)

Source.	1913.	1914.	1915.	1916.	1917.	1918.	1919.	1920.
Australia	.....	.....	.....	.....	.....	.....	.....	3
British India	.....	.....	.....	.....	.....	.....	1	.....
British South Africa	.....	.....	.....	112	1,791	837	900	2,233
Canada	96,951	71,781	93,565	114,978	131,525	134,813	133,662	162,717
China	.....	.....	.....	.....	.....	.....	1	17
Colombia	.....	.....	.....	.....	.....	1	.....	.....
England	1	.....	.....	1,072	296	.....	156	746
France	.....	.....	.....	.....	.....	.....	450	.....
Germany	19	11	1	.....	.....	.....	.....	.....
Greece	.....	.....	.....	.....	.....	.....	.....	81
Italy	6	2	.....	.....	.....	.....	.....	3
Japan	.....	.....	.....	.....	.....	.....	.....	100
Portuguese Africa	.....	.....	.....	.....	496	2,049	100	1,584
Russia in Europe	168	72	.....	.....	.....	.....	.....	.....
Turkey in Asia	.....	.....	.....	.....	.....	.....	.....	74
Total	97,145	71,866	93,566	116,162	134,108	137,700	135,270	167,558

The actual source of the asbestos in some instances is not indicated by such a table. The asbestos from England is South African, that from France is probably Cape blue, that from Germany was probably Russian fiber, from Portuguese Africa, chiefly Rhodesian, and that from Turkey and Greece was probably from Cyprus. The 100 tons from Japan was a shipment of Canadian and African fiber sent to America when the price advanced.

It is to be noted also that the figures given do not properly represent the relative importance of Canadian fiber as compared with that from other foreign countries. Canadian figures include all grades of mill fiber, which constitute the great bulk of Canadian production, the imports of crude fiber being only about 3600 tons. Imports from other countries are chiefly of crude fiber, as mill-stock grades command too low a price to justify transportation for long distances. If, therefore, high-grade fiber only is considered, the discrepancy between imports of Canadian fiber and that of other countries is not nearly so great as appears in the table. Total imports from South Africa exceed by nearly 1000 tons the imports of crude fiber from Canada. The great increase in imports of African fiber is one of the noteworthy features of the 1920 situation.

The following table gives the quantity in long tons and value of imports and exports over a series of years.

UNITED STATES IMPORTS AND EXPORTS OF ASBESTOS (a)
(In Long Tons.)

Year.	Imports.			Exports.		
	Unmanufactured.		Manufactured.	Unmanufactured.		Manufactured.
	Quantity.	Value.	Value.	Quantity.	Value.	Value.
1912	63,860	$1,456,012	$363,759	.....	.....	$601,701
1913	86,737	1,928,705	389,664	.....	.....	754,102
1914	64,166	1,407,758	368,344	.....	.....	513,037
1915	83,541	1,981,483	137,320	.....	.....	764,050
1916	103,716	3,303,470	135,064	279	$6,133	1,209,076
1917	119,739	4,521,172	65,096	632	116,580	1,932,551
1918	122,946	6,337,585	27,476	622	51,053	2,493,325
1919	120,777	7,369,685	257,381	999	157,416	3,529,348
1920	149,605	9,120,253	619,054	549	141,071	4,431,132

(a) Bureau of Foreign and Domestic Commerce.

Domestic Production.—The great bulk of spinning fiber produced in the United States is obtained in Arizona, though small quantities are mined in California and Wyoming. Asbestos suitable for filter purposes is obtained in Maryland. Amphibole asbestos used in fireproofing and insulation is obtained in Georgia, North Carolina and Washington.

A considerable increase in domestic production is to be noted in 1920. While the production in Arizona was estimated by the U. S. Geological Survey as 423 tons in 1919, in 1920 it probably exceeded 1000 tons. In the other states mentioned in the last paragraph no great increase in activity is to be noted. United States production over a series of years is shown in the following table compiled by the U. S. Geological Survey.

DOMESTIC ASBESTOS MARKETED IN THE UNITED STATES

Year.	Quantity, Short Tons.	Value.	Average Selling Price per Ton.
1914	1,247	$18,965	$15.21
1915	1,731	76,952	44.46
1916	1,479	448,214	303.05
1917	1,683	506,056	300.69
1918	1,002	124,687	124.44
1919	1,353	243,700	180.12
1920	1,710	1,154,000	674.85

It is noteworthy that Vermont, from which no asbestos has been obtained since 1912, is likely again to become a producer. The Asbestos Corporation of America has recently been chartered under the laws of Massachusetts to operate asbestos mines and mills in Vermont. Operations will be conducted on the well-known fiber-bearing deposit near Hyde Park. The product will be chiefly mill-stock grades. It is expected that production will begin some time during 1921.

The U. S. Geological Survey received reports of production from the following operators during 1920.

W. W. Bass, Grand Canyon, Ariz.
E. L. Quist, 283 S. El Molino Ave., Pasadena, Calif.
Arizona Asbestos Assoc., N. A. Nelson, Supt., Globe, Ariz.
Regal Mine (E. Schaaf Regelman), Globe, Ariz.
Globe Asbestos Co. (A. E. Minium), Globe, Ariz.
Alene Asbestos Assoc. (E. Pierce), Young, Ariz.
American Ores Asbestos Co., A. B. Shutts, Mgr., Globe, Ariz.
Penn Asbestos Mines Co., Dr. Huber, Pres., North Wales, Pa.
H. P. Wightman & Pierce, Globe, Ariz.
Sierra Asbestos Co., 704 Union Savings Bldg., Oakland, Calif.
John D. Hoff Asbestos Co., 333 Monadnock Bldg., San Francisco, Calif.
Sall Mountain Co., 203 S. La Salle St., Chicago, Ill.
Powhatan Mining Co., Woodlawn, Baltimore, Md.
American Fireproofing & Mining Co., 226 Denham Bldg., Denver, Colo.
Wyoming Asbestos Producing Co., 1014 S. Oak St., Casper, Wyo.

Canadian Activities.—There was a record production of asbestos in the Province of Quebec during 1920. During the first 6 months of the year the industry was very active, notwithstanding the inclemency of the winter weather and the difficulty in obtaining cars for shipments. During the second half of the year two of the important mines were closed for a period of 5 weeks owing to a strike. The strikers returned to work at old terms and rates. During the last 3 months of the year the American market was dull, but this had little effect on the Canadian industry, for the English and French markets absorbed much of the Canadian surplus. One result of the prosperous condition of the industry is a great extension of development work, both diamond-drilling and removal of overburden. Beginning Mar. 15, 1920, the export tax on asbestos was increased from 3½ to 5 per cent.

Canadian production for 1920 is shown in the following table.

PRODUCTION OF ASBESTOS IN THE PROVINCE OF QUEBEC FOR 1920

Designation of Grade.	Shipments and Sales.		Average Value per Ton.	Stock on Hand Dec. 31, 1920.	
	Tons.	Value.		Tons.	Value.
Crude No. 1	1,026	$1,513,457	$1,475.10	446	$659,259
Crude No. 2	2,830	2,295,927	811.28	854	829,438
Spinning fibre	13,983	3,915,562	280.02	1,929	653,115
Shingle fibre	16,784	1,852,210	110.36	1,306	172,476
Paper stocks and others	142,982	5,097,416	35.65	18,826	118,060
	177,605	14,674,572	82.62	23,361	2,432,348
Asbestic	19,716	43,559	2.20	125	274
Totals	197,321	14,718,131	.....	23,336	2,432,622

Quantity of rock mined during the year, 3,099,122 tons.

The provincial government of Quebec has proposed to enact legislation requiring asbestos companies to establish plants in the province for the

manufacture or partial manufacture of asbestos as a requisite condition for obtaining mining rights and leases. Such action would have a profound effect on American enterprises in the asbestos area, and when all phases of the question are duly considered it seems improbable that such action will be taken.

OUTPUT, SALES, AND STOCK OF ASBESTOS IN CANADA(a)

	1918.		1919.		1920.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
Output:						
Crude	4,313	.....	4,065	.....	3,734	.....
Mill stock	139,143	.....	153,507	.....	154,170	.....
Sales:						
Crude	3,692	$2,478,363	3,928	$3,214,002	3,652	$3,578,940
Mill stock	137,770	6,458,441	132,837	7,695,430	164,079	10,098,901
Asbestic	16,797	33,903	22,471	65,917	20,956	57,601
Stocks on hand, Dec. 31:						
Crude	1,686	1,109,402	1,338	974,260	1,113	1,281,733
Mill stock	12,560	941,612	31,110	1,952,629	18,283	1,324,369

(a) Summary Rept., Min. Prod. of Canada, Can. Dept. Mines; latest year from Prelim. Rept.

South African Activities.—South Africa is becoming more and more important as a source of asbestos fiber. As indicated by the table of imports on page 45, the United States obtained directly or indirectly 4563 tons of asbestos from Africa in 1920, and practically all of it was of spinning grade.

Rhodesian fiber is a high grade of chrysotile obtained in the Bulawayo and Victoria districts. While considerable Rhodesian fiber is shipped to America there is also a large demand from England and Japan. The total production for 1920 as given by the Rhodesian Chamber of Commerce was 18,823 long tons valued at £459,572. Rhodesian production over a number of years is shown in the following table:

Year.	Long Tons.	Value.
1913	290	£5,224
1914	487	8,612
1915	2,010	32,190
1916	6,157	99,059
1917	9,562	189,890
1918	8,574	158,684
1919	9,798	425,240
1920	18,823	459,572

Amosite asbestos from the Transvaal has recently attained prominence. Chrysotile is also mined in the Transvaal and in Natal, but the chief output from the Union of South Africa is the "Cape blue" or crocidolite of Cape Colony. Considerable quantities of this material are now being used in the United States.

A factory has recently been built at Meyerston 32 miles from Johannesburg for the manufacture of asbestos cement products such as sheeting, roofing tile, and paving tile.

Russia.—At the beginning of the European war Russia stood next to Canada as a producer of asbestos. The maximum production was in 1913, when it reached 19,284 short tons. The country also had 14 asbestos factories. Little or no information is obtainable as to the present condition of the industry, but it is probably almost at a standstill, as there is no record of exports during 1920.

Australia.—Asbestos has been known to exist in Australia since the days of early exploration, but the deposits of long fiber were mostly in inaccessible regions. Of late years the shorter fiber has found many uses and this has stimulated more active development. Considerable short fiber has been mined in Tasmania, but the deposits are scattered and uncertain, and scarcely justify continued operation. The most promising operations are those of Messrs. Wanderlich, and Messrs. James Hardie & Co. at Woodsreef in the New England district of New South Wales. There is little prospect of any export trade from Australia, but the country can undoubtedly supply a considerable share of its own requirements of short fiber.

China.—About 17 tons of asbestos was shipped from Hongkong to the United States during 1920. It is reported that the deposit is worked by a Chinese syndicate. Owners of asbestos mines in the Peking district are seeking American or Japanese capital to develop their properties. The available monthly output is estimated to be between 100 and 200 tons.

ASPHALT

Deposits of asphalt and allied substances are found in Kentucky, West Virginia, Arkansas, Missouri, Oklahoma, Texas, Colorado, Nevada, Utah, and California. The richest and most extensive beds are in Oklahoma, but Utah contains the largest variety of bituminous substances. The stratigraphic range of the beds is as wide as the geographic, deposits being found in strata of all ages from the Ordovician to the Recent. The oldest asphaltic formations have been observed in Oklahoma, and the youngest, which consist of recently formed sands impregnated with bitumen, occur near Carpinteria, Calif., though small superficial deposits of brea are well distributed throughout the country. The largest deposits occur as impregnated rock and veins.

Despite its wide distribution and its suitability for many commercial uses, native asphalt has not been produced in great quantities in the United States. The demand for asphaltic material has been largely met by imports and by petroleum asphalt manufactured from the low-gravity oils of California and the Gulf coastal fields. Both materials have been satisfactory and are well known wherever asphalt products are used, but petroleum asphalt is produced from oil of a grade suitable for fuel, for which there is a rapidly increasing demand for use in oil-burning ships. The large demand for asphaltic material might be met in part by bituminous rock, which could be used for paving both country highways and city streets, and if carefully laid and maintained the pavements would be durable and clean and would produce relatively little noise and dust.

European countries use large quantities of bituminous rock in building roads, and if the United States would adopt the same practice much oil that is greatly needed for use as fuel and for other purposes would be released. Although good pavements of bituminous rock have been laid in Kansas City, Kan., Oklahoma City, Okla., and a few other cities, many rock-asphalt pavements constructed in this country have not been successful because the contractor failed to understand the nature of bituminous rock. The rock differs greatly in quality, and each deposit must be analyzed and treated accordingly. Larger commercial success will probably be attained by the employment of better methods than are now generally known. The technical difficulties of utilizing bituminous rock in road surfacing appear to warrant careful research by the best chemists and paving engineers.

MARKETED PRODUCTION OF NATURAL ASPHALT AND BITUMINOUS ROCK
(In short tons)

Year.	Quantity.	Value.	Year.	Quantity.	Value.
1887	4,000	$16,000	1904	64,167	$420,701
1888	50,450	187,500	1905	62,898	305,242
1889	51,735	171,537	1906	73,062	674,934
1890	40,841	190,416	1907	85,913	928,381
1891	45,054	242,264	1908	78,565	517,485
1892	87,680	445,375	1909	99,061	572,846
1893	47,779	372,232	1910	98,893	854,234
1894	60,570	353,400	1911	87,074	817,250
1895	68,163	348,281	1912	95,166	865,225
1896	80,503	577,563	1913	92,604	750,713
1897	75,945	664,632	1914	79,888	642,123
1898	76,337	675,649	1915	75,751	526,490
1899	75,085	533,904	1916	98,477	923,281
1900	54,389	415,958	1917	80,904	735,924
1901	63,134	555,335	1918	60,034	780,808
1902	84,632	461,799	1919	88,281	682,989
1903	55,068	483,282	1920	198,497	1,213,908

PRODUCTION OF ASPHALT BY VARIETIES
(In short tons)

Variety.	1917.		1918.		1919.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Bituminous rock	41,919	$136,255	25,346	$92,238	53,589	$262,309
Wurtzilite (elaterite)	34,349	495,489	(b)	(b)	(b)	(b)
Gilsonite			30,848	606,639	(b)	(b)
Grahamite	4,618	103,180	3,803	36,532	34,692	420,680
Maltha			.....	.....	(b)	(b)
Ozokerite	18	1,000	37	905	*Nil.*	*Nil.*
Total	80,904	735,924	60,034	780,808	88,281	682,989
Manufactured or oil asphalt (a)	701,809	7,734,691	604,723	8,796,541	614,692	8,727,372
Total	782,713	8,470,615	664,757	9,577,349	702,973	9,410,361

(a) This item includes material derived from petroleum of domestic origin only.
(b) Included with grahamite.

ASPHALT PRODUCED FROM DOMESTIC PETROLEUM (a)
(In short tons)

Year.	Quantity.	Value.	Year.	Quantity.	Value.	Year.	Quantity.	Value.
1903	46,187	$522,164	1909	129,594	$1,565,427	1915	664,503	$4,715,583
1904	44,405	459,135	1910	161,187	2,225,833	1916	688,334	6,178,851
1905	52,369	452,911	1911	277,192	3,173,859	1917	701,809	7,734,691
1906	64,997	615,406	1912	354,344	3,755,506	1918	604,723	8,796,541
1907	137,948	1,898,108	1913	436,586	4,531,657	1919	614,692	8,727,372
1908	119,817	1,540,396	1914	360,683	3,016,969	1920	700,496	11,985,457

(a) U. S. Geol. Surv.

ASPHALT PRODUCED IN THE UNITED STATES FROM MEXICAN PETROLEUM
(In short tons)

Year.	Quantity.	Value.	Year.	Quantity.	Value.
1913	114,437	$1,743,749	1917	645,613	$7,441,813
1914	313,787	4,131,153	1918	597,697	9,417,818
1915	388,318	3,730,436	1919	674,876	7,771,510
1916	572,387	6,018,851	1920	1,045,779	14,272,862

DOMESTIC ASPHALT EXPORTED FROM THE UNITED STATES (a)

Year.	Unmanufactured.		Manufactures, Value.	Total Value.
	Quantity Short Tons.	Value.		
1914	41,716	$ 845,838	$401,182	$1,247,020
1915	42,787	735,952	438,685	1,174,637
1916	40,816	759,769	494,895	1,254,664
1917	30,113	586,673	586,055	1,172,728
1918	19,739	577,654	577,936	1,169,402
1919	35,900	1,103,930	606,918	1,710,848
1920	46,166	1,356,116	842,074	2,198,190

(a) Dept. of Commerce.

ASPHALT IMPORTED FOR CONSUMPTION INTO THE UNITED STATES (a)
(In short tons)

Year.	Crude.		Dried or Advanced.		Bituminous Limestone.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1912	193,645	$726,345	20,707	$177,992	3,976	$ 15,808	218,328	$921,145
1913	(b) 207,033	738,452	(c) 14,750	133,336	6,395	38,823	228,178	910,611
1914	137,352	664,558	*Nil.*	.....	1,705	11,060	139,057	675,618
1915	135,276	680,537	*Nil.*	.....	2,976	19,001	138,252	680,357
1916	147,383	733,307	*Nil.*	.....	330	1,795	147,713	735,102
1917	187,473	978,640	*Nil.*	.....	413	15,028	187,886	993,668
1918	114,686	624,967	*Nil.*	.....	39	2,528	114,725	627,495
1919	104,914	609,923	*Nil.*	.....	735	5,576	105,649	615,499
1920	127,027	1,055,951	*Nil.*	.....	1,387	11,665	128,414	1,067,616

(a) Bureau of Foreign and Domestic Commerce. (b) Includes dried or advanced asphalt for last 3 months of 1913. (c) Last 3 months of 1913 included in crude asphalt.

ASPHALT IMPORTED INTO THE UNITED STATES BY COUNTRIES
(In long tons)

Imported from	1917.(a)		1918.		1919.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Europe:						
Switzerland	100	$598	.....	.....	.....	.....
United Kingdom	363	3,666	42	$ 482	.....	.....
North America:						
Canada	95	1,742	197	4,112	34	$1,088
Mexico	609	11,210	11,579	96,125	5,863	31,587
West Indies:						
British	105,301	592,815	52,541	332,138	45,619	353,500
Cuba	4,244	32,846	50	1,783	568	17,270
South America:						
Colombia	53	1,535	.....	.....	5	169
Venezuela	51,136	258,205	38,024	192,855	42,240	211,875
Total	161,901	902,716	102,433	627,495	94,329	615,499

(a) Fiscal year ending June 30.

MINERAL WAX IMPORTED FOR CONSUMPTION IN THE UNITED STATES (a)

Year.	Quantity, Pounds.	Declared Value.	
		Total.	Price per Pound.
1914	8,191,529	$498,695	$0.061
1915	2,845,304	214,195	0.075
1916	3,047,834	200,377	0.066
1917	899,405	90,510	0.101
1918	1,809,459	147,805	0.082
1919	3,747,480	454,840	0.082
1920	4,272,341	499,758	0.117

(a) U. S. Bureau of Foreign and Domestic Commerce.

Related Hydrocarbons

Among the natural hydrocarbons are gilsonite, elaterite, wurzilite, glance pitch, manjak, grahamite, albertite, and ozokerite, and other mineral waxes. With the exception of ozokerite and other mineral waxes, they all more or less resemble asphalt in that they are dark brown or black bituminous subtances of organic origin, generally with a resinous lustre.

Gilsonite.[1]—Gilsonite or uintaite is an asphaltite characterized by a black color, conchoidal fracture, bright to fairly bright lustre, red-brown streak, specific gravity 1.01 to 1.10, hardness 2, and a melting point of 250 to 350° F. It is found only in the United States in a belt in the Uinta basin, about 65 miles long, extending from Rio Blanco County, Colorado, into Uinta County, Utah, most of the important veins being in Utah. The veins are more or less parallel, having a general strike of northwest to southeast. They vary in thickness from a few inches up to 18 ft., and some are over 8 miles long. Branch veins joining the main veins at very acute angles are common. The walls, either of limestone or shale, are nearly vertical, and are often so impregnated with gilsonite for several feet that no sharp line of demarcation exists. Close to the walls the gilsonite has the characteristic columnar structure perpendicular to the walls which is common to all asphaltites. Near the outcrop gilsonite loses its brilliant lustre and becomes a dull black through weathering. The methods of mining gilsonite are crude, little machinery being used. Little or no timbering is necessary, as the walls are usually strong and stand well. The ore is hoisted from underground, sorted, and packed in bags.

Two grades are marketed, "selects" or "firsts," and "seconds." Selects are taken from the center of the vein and have a bright lustrous conchoidal fracture. Seconds come from near the walls and have a semi-conchoidal and semi-lustrous fracture. Gilsonite is used principdall for the manufacture of paints, varnishes, and japans, and it is regayerd by some as the most valuable hydrocarbon for this purpose. Unlike

[1] U. S. Bureau of Mines.

grahamite, gilsonite and glance pitch will mix in all proportions with fatty-acid pitches. Such mixtures are utilized for a great variety of purposes. Gilsonite is also used to a large extent in the rubber industry. Pure rubber is sensitive to heat and cold, but a vulcanized mixture of gilsonite and rubber has different physical and chemical properties, and will resist both oxidation and changes in temperature. In such instances gilsonite may not be regarded as an adulterant, but as a valuable constituent. Gilsonite also is used to some extent in prepared roofings and flooring materials, in paving cements, and, when mixed with other hydrocarbons, in pressed and moulded insulation, electrical insulating tape, etc.

Ozokerite.[1]—The largest domestic deposits of ozokerite are in Utah, near Colton, Utah County, and Soldier Summit, Wasatch County, along the Denver and Rio Grande Railroad, about 90 miles from Salt Lake City. During the war the Soldier Summit deposits were reopened, a new plant installed, and production started on an important scale. The ozokerite occurs as a filling of brecciated zones in fissure veins in sandstones and shales. The veins vary in width up to 5 or 6 ft., and the ozokerite in the veins from mere films to 22 in. The ore from the mine is sorted, crushed, and subjected to a refining process. Several methods have been used, varying principally in mechanical details, but the underlying principles are similar. The ore is placed in steam-heated vats with water and raised to a temperature of 54 to 70° C. The wax melts and floats off as a liquid into cooling-vats, while the rock is removed either continuously or intermittently from the bottom. The impure wax is purified by a second boiling, and the tailing from the first tanks is retreated, producing an impure wax which is later purified, a middling product which is returned to the first tanks, and clean tailing which is wasted. The purified wax is heated in an open tank to remove trapped moisture, and then cast or moulded into blocks for market.

Ozokerite may be used either as the purified wax or as ceresine, which is made by further refining ozokerite. The wax may be purified by mixing with alkali and filtering through fuller's earth, animal charcoal, or magnesium silicate.

Ozokerite vaseline is made by filtering ozokerite through animal charcoal twelve to thirty times, and distillation with superheated steam as 250° C. for 3 or 4 hr. Ozokerite is used for the manufacture of wax figures, dolls, and candles; as a substitute or adulterant for beeswax; as a covering to protect metals from moisture, acids, and alkalies; for making waxed paper; for lining barrels, kegs, and acid tanks; as a foundation for waxes, polishes, liniments, salves, and plasters; for imitation alabaster statuettes and decorations for confections; for artificial honeycombs; for

[1] U. S. Bureau of Mines.

making boot-blacking and polish, varnish, shoemaker's wax, and floor-wax; as a base for a variety of lubricants from axle-grease to gun-oil; in the manufacture of leather-polish, sealing-wax, and pomades; and as electrical insulation. A very large and important use is as an acid-proof coating for electrotypers' plates.

Montan Wax.[1]—Montan wax comes into commerce as a white, high-melting candle-like material. It is not a paraffine, but a mixture of an acid and an alcohol. While it decomposes when distilled at ordinary pressure, it may be purified by distillation with superheated steam in vacuum.

Montan wax is valuable as a substitute for carnauba wax in the manufacture of shoe-polishes, and is also used in the manufacture of phonographic records, and as an insulating material in place of ceresin (purified ozokerite).

The best source of Montan wax is the mineral pyropissite, which may contain as high as 70 per cent. This supply, however, is largely exhausted. The next best material is lignite from Thuringen, Saxony, with

WORLD'S PRODUCTION OF ASPHALT AND BITUMINOUS ROCK (*a*)
(In metric tons)

Asphalt.

Year.	France.	Germany.	Hungary.	Italy. (*c*)	Spain.	Trinidad. (*b*)	United States. (*e*)	Total.
1910...	38,500	81,208	4,994	41,705	8,473	161,587	31,159	367,626
1911...	38,000	81,902	3,861	50,179	3,495	163,080	40,307	380,824
1912...	31,535	96,112	4,460	52,707	6,087	176,077	37,570	403,888
1913...	30,892	105,500	3,024	56,750	5,695	208,164	31,810	441,835
1914...	22,170	81,800	.....	33,752	4,148	147,942	26,147	315,959
1915...	10,179	32,400	.....	25,201	2,671	138,210	28,506	237,167
1916...	17,559	.....	.....	16,662	2,591	133,204	32,028	.....
1917...	12,964	12,321	.....	13,608	1,950	132,742	35,367	.....
1918...	11,961	.....	.....	8,310	2,367	74,254	31,469	.....
1919...	11,065	.....	.....	14,872	2,385	95,312	48,616	.....

Bituminous Rock.

Year.	Austria.	France.	Hungary.	Italy.	Spain.	United States.	Total.
1910.....	1,066	170,000	(*d*)70,000	162,212	.....	58,581	469,654
1911.....	1,740	169,697	(*d*)60,000	188,133	.....	38,704	464,774
1912.....	4,234	312,000	(*d*)50,000	181,397	.....	49,691	597,322
1913.....	3,026	324,610	45,860	171,097	.....	(*f*)52,220	601,451
1914.....	.....	166,125	.....	119,853	5,765	44,257	.....
1915.....	.....	66,831	.....	47,650	4,521	40,210	.....
1916.....	.....	98,480	.....	16,829	7,316	57,311	.....
1917.....	.....	116,679	.....	8,645	.....	38,028	.....
1918.....	.....	104,234	.... 17,600...	22,309	8,395	22,994	.....
1919.....	.....	.....	.....	78,000	10,091	31,475	.....

(*a*) Statistics of production in Barbados, Cuba, Mexico, Russia, Switzerland, and Venezuela are not available. (*b*) Exports. (*c*) Including mastic and bitumen. (*d*) Estimated. (*e*) Previously the U. S. statistics included oil asphalt. This is now omitted, leaving only the natural asphalt. (*f*) Includes some maltha.

[1] C. J. West, *Chem. Met. Eng*

about 9 per cent. Montan wax, although in exceptional cases as high as 20 per cent. has been obtained. All the other lignites examined run somewhat below 5 per cent. Montan wax.

Foreign Sources

Trinidad.—The asphalt occurrences of Trinidad were discovered in 1499 by Columbus, on his third voyage to America, and the material met its first use at his hands, as a caulking material for his ships. A hundred years later Sir Walter Raleigh visited the island and used the asphalt for the same purpose, recording in his diary the excellence of the material for that purpose. The asphalt occurs in a lake located in the center of an extinct volcano, and since the time of Columbus and Raleigh more than 4,000,000 tons of asphalt has been removed from the lake without appreciably diminishing the supply.[1]

The output of asphalt in 1919 was 93,806 tons, valued at $272,088, an increase of 9775 tons over the preceding year.[2]

TOTAL EXPORTS OF ASPHALT FROM TRINIDAD, 1912–1918 (*a*)
(In long tons)

Year.	To United States.			To Europe.			To Other Countries.			Grand Total.
	Lake.	Land.	Total.	Lake.	Land.	Total.	Lake.	Land.	Total.	
1912	95,111	8,600	103,711	85,299	.....	85,299	486	.....	486	189,496
1913	123,873	1,400	125,273	104,153	.....	104,153	605	.....	605	230,031
1914	67,357	2,950	70,307	75,297	.....	75,297	.....	.....	.....	145,604
1915	118,001	1,250	119,251	18,025	.....	18,025	.....	.....	.....	136,026
1916	117,719	.....	117,719	13,380	.....	13,380	.....	.....	.....	131,099
1917	119,149	.....	119,149	11,496	.....	11,496	.....	.....	.....	130,645
1918	58,528	.....	58,528	14,552	.....	14,552	.....	.....	.....	73,080

(*a*) U. S. Geol. Surv., through courtesy of Barber Asphalt Paving Co.

Venezuela.—The production of asphalt in Venezuela by companies in recent years is shown in the following table:[3]

ASPHALT PRODUCED IN VENEZUELA
(In metric tons)

Company.	Location.	1917.	1918.	1919.
New York & Bermudez Co.	Guanoco, State of Sucre	52,991	46,453	45,932
South American Company	Gen. Urdaneta and of Lagunillas, State of Zulia	72	50	.....
Cià. Anonima Minerales Petroliferous Riopauji	Rio Pauji, State ofTrujillo	1,009	.....	.....
Total		54,072	46,503	45,932

[1] H. T. MacFarland, *Min. Oil Bull.*, Oct., 1920.
[2] *Comm. Rept.*, Nov. 27, 1920.
[3] A. H. Redfield, *Eng. Min. Jour.*, Feb. 19, 1921.

The asphalt lake in Venezuela is worked by the New York & Bermudez Co., a subsidiary of the General Asphalt Co. Most of the output is exported to the United States. Exports for several years are shown below:[1]

	Quantity, Short Tons.	Value.
1906	24,783	$98,250
1907	42,153	167,938
1908	35,324	141,912
1909	41,767	180,061
1910	35,717	151,000
1911	56,183	238,000
1912	73,780	312,000
1913	93,884	400,000
1914	49,941	.....
1915	31,949	.....
1916	49,176	.....
1917	54,410	.....
1918	47,314	.....
1919	41,582	.....

Madagascar.—The Pearl Bitumen Transport & Trading Co., Ltd., has secured control of some 80 square miles of territory on the western side of the island of Madagascar, in which occur large deposits of bitumen.[2]

Peru.—In the departments of Junin and Lima, in Central Peru there are four distinct districts in which asphalts are mined and used as fuel. These asphalts have attracted considerable attention due to the fact that their ashes contain from 1 to 15 per cent. of V_2O_5.[3]

[1] U. S. Geol. Surv.
[2] *So. Afr. Min. Eng. Jour.*, July 3, 1920.
[3] J. G. Baragwanath, *Eng. Min. Jour.*, May 7, 1921.

BARIUM AND STRONTIUM

By J. B. Pierce, Jr.

Barium

Detailed figures for output and consumption during the year 1920 are not available at the time of writing, except for Tennessee. The 1920 data for this State, as supplied by the Tennessee Department of Mines, is given in the following table:

CRUDE BARYTES PRODUCED IN TENNESSEE IN 1920

Total quantity produced (short tons)	19,014
Total value of barytes produced	$111,000.00
Average value per ton	$5.84
Total amount paid for labor	$63,528.00

MARKETED PRODUCTION OF CRUDE BARYTES IN THE UNITED STATES

	Short Tons.		Short Tons.		Short Tons.
1903	50,397	1909	61,945	1915	108,547
1904	65,727	1910	42,975	1916	221,952
1905	48,235	1911	38,445	1917	206,888
1906	50,231	1912	37,478	1918	155,241
1907	89,621	1913	45,298	1919	189,647
1908	38,527	1914	52,747	1920 (estimated)	195,700

The United States Geological Survey has published estimates for the marketed production of the other states in 1920. These are shown in the table below, together with the corrected figures for 1918 and 1919.

CRUDE BARYTES MARKETED IN THE UNITED STATES[1]

State.	1918.			1919.			1920.		
	Quantity (Short Tons).	Value.	Average Price Per Ton.	Quantity (Short Tons.)	Value.	Average Price per Ton.	Quantity (Short Tons).	Value.	Average Price per Ton.
Alabama	794	$9,976	$5.56	(a)	(a)	(a)	(a)	(a)	(a)
Georgia	69,138	418,178	6.03	85,303	$667,521	7.83	85,000	$795,000	$9.35
Kentucky	(a)	(a)	(a)	5,435	36,408	6.70	(a)	(a)	(a)
Missouri	49,094	393,738	8.02	53,564	463,369	8.74	77,000	792,000	10.29
North Carolina	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Tennessee	22,542	141,844	6.29	34,700	288,622	8.32	19,014	63,528	5.84
Other States(b)	16,620	81,169	6.43	10,645	94,873	8.91	14,700	127,300	8.66
	155,368	1,044,905	6.73	189,647	1,555,793	8.20	195,714	1,777,828	9.08

[1] U. S. Geol. Surv.
(a) Included in "Other States."
(b) Includes Alabama, Kentucky, Nevada, New Mexico, North Carolina, South Carolina Virginia and Wisconsin.

CRUDE BARYTES USED IN THE MANUFACTURE OF BARIUM PRODUCTS[1]

	For Barium Chemicals.	For Ground Barytes.	For Lithopone.	Total.
1916	38,283	75,507	71,898	185,688
1917	49,842	60,132	86,065	196,039
1918	38,041	62,440	85,282	183,783
1919	32,976	64,922	103,688	201,586
1920 (estimated)	33,800	73,600	117,900	225,300

[1] U. S. Geol. Surv., short tons.

CRUDE BARYTES IMPORTED FOR CONSUMPTION[1]

Year.	Quantity (Short Tons).	Value.	Year.	Quantity (Short Tons).	Value.
1913	35,840	$61,409	1917	6	$63
1914	24,423	46,782	1918	*Nil.*	*Nil.*
1915	2,504	4,877	1919	118	594
1916	17	245	1920	24,874	146,858

[1] Bur. of Foreign and Domestic Commerce.

The barytes industry, in common with many others, suffered a severe decline in the closing months of 1920. This was accelerated by reports of importations of ore from Germany.

The question of tariff appears to be the critical turning point of the whole barium business, both barytes and manufactured products. In an effort to arrive at an equitable rate, the United States Tariff Commission went into the matter of the extent of barytes deposits in the United States, freight-rates, costs of mining, etc., all of which is set forth in their Tariff Information Survey on Barytes, Barium Chemicals and Lithopone. This survey is probably the most complete and comprehensive gathering together of reliable data on the barium industry as a whole that has ever been compiled.

COST OF MINING BARYTES IN THE UNITED STATES DURING 1919 (*a*)
(Per short ton)

	Total Cost.		Detail of Total Cost as Reported (Column 2).				
1.	2.	3.	4.	5.	6.	7.	8.
	As Reported.	On Uniform Amortisation and Royalty Basis.	Labor in Mining.	Transportation to Shipping Point.	Weighing and Loading.	Amortisation and Royalties.	Other Expenses.
Weighted average cost	$7.74	$7.97	$4.38	$2.01	$0.20	$0.54 0.77(*b*)	$0.61

(*a*) Tariff Information Surveys, U. S. Tariff Commission. (*b*) Uniform charge for amortisation and royalties used in arriving at total cost as in column 3.

COST OF MINING BARYTES IN SOUTHERN MINES DURING 1919 (a)
(Per short ton)

	Total Cost.		Detail of Total Cost as Reported (Column 2).			
1.	2.	3.	4.	5.	6.	7.
	As Reported.	On Uniform Amortisation and Royalty Basis.	Labor in Mining.	Supplies in Mining.	Amortisation and Royalties.	Other Expenses.
Weighted average cost.....	$7.39	$6.31	$2.82	$0.46	[$1.71 [0.63(b)	$2.40

(a) Tariff Information Surveys, U. S. Tariff Commission. (b) Uniform charge for amortisation and royalties used in arriving at the total cost as in column 3.

Barium Chemicals.—The close of 1920 saw an almost complete shutdown of the barium chemical plants in the United States. This was due to the general slowing down of business and to the resumption of importations of German goods, which have been coming in steadily since the late fall of 1920.

BARIUM CHEMICALS OF DOMESTIC MANUFACTURE SOLD
(In short tons)

Chemical.	1915.	1916.	1917.	1918.	1919.	1920.
Barium binoxide.....	306	1,980	2,555	1,047	858	(a)
Barium carbonate.....	2,746	6,844	8,238	7,661	7,135	7,484
Barium chloride.....	2,106	3,643	4,870	4,530	4,509	3,084
Barium nitrate.....	971	446	165	137	784	(a)
Barium sulphate (blanc fixe).....	1,229	3,337	6,314	9,022	5,227	6,946
Other barium chemicals (b).....	1,465	542	361	289	1,500	2,951
	8,823	16,792	22,503	23,186	20,013	20,465

(a) Included under "Other barium chemicals." (b) Includes, 1915: Hydroxide, sulphide, and other barium chemicals not specified; 1916: Hydroxide and sulphide; 1917: Hydroxide and sulphide; 1918: Hydroxide and sulphide; 1919: Sulphide; 1920: Binoxide, hydroxide, nitrate and sulphide.

IMPORTS OF BARIUM PRODUCTS
(Fiscal year, ending June 30)

	1917.		1918.		1919.		1920.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Baryta, sulphate of, or barytes including baryta earth:								
Unmanufactured, long tons..	5	$63	*Nil.*	*Nil.*	105	$594	2,058	$10,405
Manufactured, long tons....	210	3,813	*Nil.*	*Nil.*	*Nil.*	*Nil.*	107	653
Blanc fixe, or artificial sulphate of barytes, and satin white or artificial sulphate of lime, pounds.....	408,163	10,029	179,200	$2,376	1,285	90	41,108	1,267
Lithopone, pounds.....	231,869	20,591	448,000	29,199	1,477,296	122,708	2,288,955	170,522
Barium carbonate, pounds....	804	177	106,288	1,437	8,549	2,666	163,509	18,268
Barium binoxide, pounds.....	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	70,862	12,367
Barium chloride, pounds.....	6,614	608	*Nil.*	*Nil.*	1,099,686	19,756	2,520,321	71,988

Detailed figures regarding production cannot be given at the time of writing, but it is a safe estimate to say that production will not be over two-thirds of that in 1919, and the outlook for any considerable production in 1921 is very poor, unless a tariff law, carrying sufficiently high duties to enable the domestic manufacturer to operate, is enacted without delay.

COSTS OF MANUFACTURING BARIUM CHEMICALS DURING 1919 (*a*)
(Per pound)

Name of Product.	Manufacturers Reporting.	Total Cost.	Material.		Labor.		Overhead and Selling Expense.	
			Cost.	Per Cent. of Total.	Cost.	Per Cent. of Total.	Cost.	Per Cent. of Total.
Barium carbonate	3	$0.0316	$0.0167	52.9	$0.0038	12.0	$0.0111	35.1
Barium peroxide	3	0.197	0.088	44.7	0.046	23.3	0.063	32.0
Blanc fixe (*b*)	3	0.0294	0.0160	54.4	0.0028	9.5	0.0106	36.1
Barium chloride	4	0.0539	0.0218	40.5	0.0109	20.2	0.0212	39.3

(*a*) Tariff Information Surveys, U. S. Tariff Commission.
(*b*) Precipitated barium sulphate.

Lithopone.—Apparently the lithopone production stood up better at the end of 1920 than either the barytes or barium chemical production. This was probably due to two causes: (1) Lithopone, having a wider application, that of a pigment, was slower to be affected by the general business depression than barium chemicals. (2) The factor of imported goods does not enter so strongly here, as in 1914 89.7 per cent. of the lithopone sold in the United States was manufactured here, as against only 10 per cent. of barium chemicals.

PRODUCTION AND CONSUMPTION OF LITHOPONE IN THE UNITED STATES

Year.	Production. (*a*)		Imports. (*b*)		Consumption (Pounds).
	Quantity (Pounds).	Value.	Quantity (Pounds).	Value.	
1911	33,732,000	$1,243,108	6,355,312	$166,199	40,087,312
1912	48,440,000	1,702,119	5,904,475	153,303	54,344,475
1913	59,370,000	2,170,445	4,504,423	122,063	63,424,423
1914	65,638,000	2,490,530	7,544,148	259,955	73,182,148
1915	92,988,000	3,760,472	4,087,826	137,816	97,075,826
1916	102,582,000	5,798,927	4,681,560	405,730	107,263,560
1917	127,426,000	7,394,531	448,000	29,199	127,874,000
1918	124,806,000	7,923,209	.....	.....	124,806,000
1919	156,730,000	10,218,850	1,477,296	122,708	158,207,296
1920	198,746,000	12,484,925	.....	263,240	.....

(*a*) 1910 to 1918, inclusive, from "Mineral Resources," U. S. Geol. Surv. 1919 from reports submitted to the Tariff Commission by individual manufacturers. (*b*) From 1910 to Oct. 3, 1913, listed as "white sulphide of zinc."

WEIGHTED AVERAGE COST OF LITHOPONE DURING 1919 (a)

Production (Pounds).	Total Cost.	Material Cost.	Direct Labor Cost.	Factory Overhead.	Selling Expense.	Average Sales Price.	Apparent Average Profit.
142,519,176	$0.0602	$0.0259	$0.0108	$0.0204	$0.0031	$0.0667	$0.0065

(a) Tariff Information Surveys, U. S. Tariff Commission.

STATISTICS OF BARYTES IN THE PRINCIPAL COUNTRIES
(Metric tons)

	1913.	1915.	1916.	1917.	1918.	1919.
Austria-Hungary (exports)						
Barium chloride	4,918	.....	.....	.....	.....	.....
Barytes	753	.....	.....	.....	.....	.....
Belgium (production)	12,000	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*
Canada (production)	582	499	1,241	3,166	581	*Nil.*
France (production)	12,236	.....	.....	.....	.....	.....
Baden (production)	16,445	.....	.....	.....	.....	.....
Bavaria (production)	27,199	.....	.....	.....	.....	.....
Germany (exports)						
Barytes	158,065	.....	.....	.....	.....	.....
Barium white	7,647	.....	.....	.....	.....	.....
Barium chloride	5,649	.....	.....	.....	.....	.....
Barytes (imports)	19,466	.....	.....	.....	.....	.....
Italy						
Barytes, crude (production)	12,970	17,850	21,650	19,000	14,945	19,390
Barytes (imports)	1,771	1,319	1,398	1,121	1,064	795
Barytes (exports)	234	3,288	2,755	1,113	523	1,977
Spain (production)	3,049	4,218	10,508	10,147	4,170	11,459
Sweden (imports)	610	1,665	3,308	.....	.....	.....
United Kingdom (production)	48,792	63,483	77,258	66,612	67,428	61,054
United States (imports)	37,490	3,460	149	84	*Nil.*	107
United States (production)	41,105	98,500	202,355	187,689	140,834	172,370

Great Britain.[1]—Barium minerals occur as barytes (sulphate of barium) and witherite (carbonate of barium), the latter forming only a small proportion of the production. The present British production (66,360 long tons in 1918 and 60,087 tons in 1919) is about 22 per cent. of the world's production and 66 per cent. of the normal home consumption. Barytes is in part a by-product of lead and zinc mining; but the larger proportion is mined independently, and the production can be largely increased. This material was regarded by the ancient miners as of no value, the first recorded production of barytes being in 1860. Consequently, although it occurs chiefly in the upper portion of the lodes, being one of the last minerals to be deposited from the upward-traveling solutions, it is found in abundance by present-day miners. With increasing depth the barytes generally carries more and more galena and loses value as a commercial product.

The market price depends chiefly on the color (which means freedom from oxides of iron and manganese) and on fine grinding, the material being graded on these qualities. The snow-white, finely-ground material is used in the paint trade and in paper manufacture, while the

[1] *Comm. Rept.*, July 6, 1920.

inferior grades are used for colored paints, lithopone, in the motor-tire industry, and for many other purposes. Much of the British output of barytes is of the varieties known as "crude," "brown," and "off-color," but experiments are being carried out to improve the processes of grinding, grading, and bleaching in order to raise the standard of the products to the level of the material imported from Germany and Belgium before the war. The industry is in an unsettled condition, owing to the fear of foreign competition, and the Government has been asked for assistance to prevent dumping.

STRONTIUM

During the year 1920 the strontium industry was practically at a standstill. This applies both to the mining of the crude ore, celestite, and the manufacturing of strontium products. So far as can be ascertained at this time, there was no development or production of celestite in this country during the year.

STRONTIUM ORE MARKETED AND IMPORTED IN THE UNITED STATES (a)
(In short tons)

Year.	Production.	Value.	Imports, Value.
1916	250	$3,650	$11,049
1917	4,035	87,700	23,216
1918	400	20,00	2,459
1919	*Nil.*	*Nil.*	3,380
1920	*Nil.*	*Nil.*	15,479

(a) U. S. Geol. Surv.

It has been reported that a small amount of strontianite was mined in California. A small quantity of celestite was imported from England. This was used to manufacture strontium nitrate, which was the only strontium product manufactured in the United States in 1920.

BISMUTH

By A. T. Ward

Bismuth is a silver-white metal with a pinkish tint, having a specific gravity of 9.80 (as compared with 11.37 for lead), and a melting point of 266° C. It volatilizes at between 1100 and 1450° C.

The peculiar properties of bismuth are principally as follows:

1. It expands on solidifying, its specific gravity just above the melting point being 10.55. This property is utilized in stereotype alloys where an especially clear impression of the type is required.

2. It is the most diamagnetic material known.

3. It is capable of combining with various other metals, such as lead, tin and cadmium, into alloys which have many special uses, such as for fusible plugs which operate automatic fire sprinklers, these being alloys which melt at temperatures below the boiling point of water; among these various alloys are:

Darcet's metal, containing 50 per cent. bismuth, and melting at 93° C.

Guthrie's metal, containing 47.38 per cent. bismuth and 13.29 per cent. cadmium, melting at 71° C.

Lipowitz's metal, containing 50 per cent. bismuth and 10 per cent. cadmium, and melting at 70° C.

Various other alloys of this nature are: Newton's metal, Onion's alloy, Rose's metal, and Wood's metal, all of which contain 50 per cent. or more of bismuth and melt at temperatures lower than the boiling point of water.

Other uses for bismuth are in porcelain painting and enameling, in staining glass, in dental solders and amalgams, in alloys used in making casts of objects which would be destroyed by heat, in silvering mirrors and in electrical fuses, etc.

Bismuth is produced by one of the following methods:

1. By liquation in crucibles or retorts of ores carrying native bismuth.

2. By reduction processes, using sodium carbonate as a flux, besides lime and iron oxide, since the fusion temperature of the slag must be low.

3. As a by-product of electrolytic lead refining by the Betts process, where the metal is contained in the slimes. The metal is refined electro-

lytically in chloride solution carrying an excess of hydrochloric acid, the current density being from 15 to 30 amp. per sq. ft. Anodes are argentiferous and auriferous bismuth, and the cathodes of sheet lead, the process taking place in porcelain tanks. This process gives the purest bismuth and is in use at the U. S. Smelting Lead Refinery, Inc., East Chicago, Ind., and by the American Smelting & Refining Co. At the end of 1920 the production of the latter plant was nominal only.

4. As a by-product of steam Pattisonizing (Hulst process).

5. As a result of the wet treatment of the last oxide coming from the cupellation of lead-silver bullion.

6. As a by-product of electrolytic copper refining, where the metal is contained in the slimes. Blister copper from Iron Mountain (Shasta County, Calif.) ores have been noted as carrying 27.3 lb. of metallic bismuth for 100 tons of blister.

Bismuth production in the United States is confined principally to a few lead and tin refineries such as those of the U. S. Smelting, Refining and Mining Co., and the American Smelting and Refining Co. Production of metal outside of the United States, principally in England, Australia and Germany, is from ores from the following sources:

Bolivia: Tin mines of Aramayo, Francke & Co., at Tazna and Chorolque; tin mines at Llallagua and Uncia, as well as in the Huayna Potosi district.

Peru: Mine of E. E. Fernandini in Cerro de Pasco. This mine produces ore containing 1.5 to 2 per cent. Bi, which is concentrated at the Huaraucaca mill to 20 per cent. Bi. In May, 1920, 189 bars of bismuth of 81 to 92 per cent. Bi smelted at this plant were exported to Great Britain.

Australia: Small mines in Queensland, New South Wales and Tasmania; it is reported that there are unsold stocks of Australian bismuth now in the United States.

China: During 1920 comparatively heavy shipments of bismuth ores from Southern China were made to both the United States and England. These ores were by-products of tungsten mining.

Other countries: Mexico, Spain, Chile, Norway (Kjenner mine) and Saxony have been reported from time to time as producing small quantities of bismuth minerals.

The greater part of the bismuth produced outside of the United States is controlled by Messrs. Johnson, Matthey & Co., Ltd., of London, while the American production is controlled by the lead and copper refiners noted.

The following table gives the imports of bismuth into the United States for the fiscal years since 1910: (*a*)

Year.	Quantity, Lb.	Value.
1910	200,321	$316,838
1911	178,298	321,360
1912	166,980	305,282
1913	151,030	257,176
1914	138,190	241,448
1915	34,237	72,587
1916	64,821	155,925
1917	88,465	196,113
1918	85,611	208,098
1919	76,539	228,376
1920	75,781	97,489

(a) Dept. of Commerce.

The major consumption of bismuth is in salts for pharmaceutical purposes.

It is reported that in 1920 quotations for bismuth in the United States ranged from $2.85 per lb. early in the year to $2.40 per lb., while the market abroad remained unchanged at approximately 12s. 6d. per lb.

WORLD'S PRODUCTION OF METALLIC BISMUTH AND BISMUTH MINERALS
(In metric tons)

Year.	United States, Metal.	Australia, Minerals. (c)	Bolivia, Minerals.	Spain, Minerals.	Peru, Metal. (b)	China, Minerals.
1909	.....	19.2	.....	76.5	30.3	.....
1910	.....	27.8	.....	52.0	24.1	.....
1911	.....	18.0	550	51.0	24.4	.....
1912	.....	11.0	478	71.7	51.0	.....
1913	.....	15.3	422	55.0	25.3	.....
1914	.....	21.9	460	39.3	11.2	.....
1915	.....	26.5	570	16.7	.....	.....
1916	.....	38.2	680	10.8	.....	.....
1917	.....	13.2	251	13.7	1.4	.....
1918	.....	57.5	143	33.4	.....	.....
1919	145(a)	23.7	374	75.0	.....	86(a)
1920	114(a)	.....	.....	.....	7.8	.....

(a) Estimated. (b) From *Estadistica Minera del Peru*. (c) Exclusive of bismuth-tungsten minerals.

BORAX

By A. T. Ward

Borax or sodium borate, $Na_2B_4O_7$, is a white powder of specific gravity 1.83.

The principal uses of boron compounds are as follows:

1. In the pottery and enamel industries, for glazes and enamels (borax).
2. In the manufacture of glass (borax).
3. In the manufacture of soap (borax).
4. In the tanning and glue industries (borax).
5. In the food industry, as a preservative (borax).
6. In paper and linen industries, for glazes (borax).
7. In metallurgical industries as: a flux in brazing and welding (borax); a slagging element in reduction processes (borax); and an energetic deoxidizer or scouring agent (boron fluoride). This latter compound as an occluded gas is absorbed in such metals as aluminium, copper, nickel, manganese, and silver, which are used in small quantities as the scouring or purifying agent.

Boron, when alloyed in small amounts with aluminium, copper, steel, nickel, and bronze, has been noted as improving the density, hardness and strength.

8. In the paint industry, as a drying agent (borates of manganese and lead), and in the pigment industry for calico printing (borate of chromium).
9. In generating pure hydrogen peroxide (perborate of sodium and calcium).

Of the entire world's production of boron, by far the larger part is produced and used as borax, obtained chiefly from the mineral borates of lime by treating them with alkalies. Boric or boracic acid, next in quantity of use, is obtained by treating ground borates with sulphuric acid.

The principal sources of the world's borax materials are as follows:[1]

United States.—Colemanite deposits of the Furnace Creek area of the Death Valley region, California, controlled by the Pacific Coast Borax Co. Borax is obtained from colemanite by treatment with sodium bicarbonate.

[1] "Borates (1913–1919);" published by the Imperial Mineral Resources Bureau, London, 1920.

The American Trona Corporation produced borax during 1920 from fractional crystallization of concentrated brines obtained from Searles Lake.

Chile, Peru and Bolivia.—Ulexite or boronatrocalcite deposits, almost wholly owned and worked by the British company, Borax Consolidated. The most important deposit and the center of practically all of the borate mining of Chile is that in the desiccated lake known as the Salar de Ascotan, on the Antofagasta and Bolivia Railway. This lake is 24 miles long and 6 miles wide at the broadest part and is situated in the High Andes in the vicinity of recent volcanoes, at an altitude of 12,200 ft.

The Peruvian production comes from the Salinas deposit located in the Department of Arequipa, and it is understood that a project for increasing the production from this locality to 20,000 tons annually is under consideration.

Argentine.—Ulexite deposits, principally under control of the International Borax Co. at Tres Morros and in Los Andes, Jujuy, Salta and Catamarca.

Italy.—Sassolite or crystallized boric acid from fumerole deposits in the province of Pisa.

Asia Minor.—Pandermite deposits at Sultan-Chair, between the Manissa-Sona-Panderma branch of the Smyrna-Cassaba Railway.

India.—Tincal deposits from Tibet and from salt lakes in the Puga Valley of Ladakh, Kashmir. Annual production approximates 1100 metric tons.

WORLD'S PRODUCTION OF BORAX MATERIALS
(In metric tons)

Year.	United States.	Chile.	Peru.	Argentine.	Italy.	Asia Minor.
1913	52,600(a)	50,225(b)	2,001(b)	933(b)	2,410(d)	.....
1914	50,609(a)	31,907(b)	1,263(b)	613(b)	2,537(d)	.....
1915	60,785(a)	15,899(c)	648(c)	192(c)	2,497(d)	.....
1916	93,918(a)	13,023(c)	1,302(c)	86(c)	2,293(d)	.....
1917	98,771(a)	8,919(c)	306(c)	.....	2,335(d)	.....
1918	80,735(a)	7,482(c)	528(c)	779(c)	2,210(d)	.....
1919	60,007(a)	9,959(c)	518(c)	1,971(c)	2,063(d)	6,929(c)
1920	109,154(a)	16,754(c)	263(c)	1,687(c)	.....	6,783(c)

(a) U. S. Geol. Surv. (b) Imperial Mineral Resources Bureau, London. (c) Authoritative private information. (d) Ministero di Agricoltura, Rome.

UNITED STATES

The quantity of borax produced and sold in the United States in 1920 was 35,280 short tons, valued at $5,674,000, according to the United States Geological Survey. This is a record production and value, exceeding even those of 1919—28,518 tons and $4,351,891—which were higher than those of any previous year.

The total quantity of crude borates produced in the United States in

1920 amounted to 120,320 tons, valued at $2,173,000. This is a record in quantity, though not in value, on account of the lower grade of the ores.

In the United States a considerable quantity of boric acid is made from borax as well as from colemanite. Boric acid is an antiseptic and is also used in cosmetics. It is also employed to preserve meats under conditions permitted by the Food and Drugs Act.

Figures showing the exports of borax and boric acid are not available, and the imports are relatively insignificant.

The price of borax in 1920 as quoted in the New York market, for crystals in bags, in car lots, averaged about 9½ cts. a lb. The price in 1919 was about 8½ cts. a lb.

UNITED STATES IMPORTS OF BORAX, ETC.
(Fiscal years ending June 30)

Year.	Borax.		Borate of Lime, Etc.		Boracic Acid.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1914	466	$ 64	220	$29	527,201	$22,390
1915	*Nil.*		*Nil.*		401,684	18,002
1916	*Nil.*		*Nil.*		424,219	22,145
1917	83	3	*Nil.*		404,210	24,590
1918	*Nil.*		*Nil.*		195,650	14,087
1919	*Nil.*		550	25	280,935	31,190
1920	*Nil.*		*Nil.*		253,958	11,165

PRODUCTION OF BORATE ORES IN CALIFORNIA (*a*)
(In tons of 2000 lb.)

Year.	Tons.	Value.	Year.	Tons.	Value.	Year.	Tons.	Value.
1907	53,412	$1,200,913	1912(*d*)	42,318	$1,127,813	1917(*d*)	108,875	$3,609,632
1908	22,200	1,117,000	1913(*d*)	58,051	1,491,530	1918(*d*)	88,794	2,179,830
1909	16,628	1,163,960	1914(*d*)	62,400	1,464,400	1919(*d*)	66,146	1,380,000
1910(*d*)	42,357	1,201,842	1915(*d*)	67,003	1,677,099	1920(*d*)	120,320	2,173,000
1911(*d*)	53,330	1,569,151	1916(*d*)	103,525	2,409,459			

(*a*) Reported by the California State Mining Bureau. (*d*) U. S. Geol. Survey, crude.

Borax was produced in the United States in 1920 by the American Trona Corporation, 233 Broadway, New York City; the Pacific Coast Borax Co., 100 William Street, New York City; Chas. Pfizer & Co., 81 Maiden Lane, New York City; Thorkildsen, Mather & Co., 111 West Monroe St., Chicago, Ill. The West End Chemical Co., at Searles Lake, expects to begin marketing borax in the near future.

BROMINE AND IODINE

By A. T. Ward

Bromine

Bromine at ordinary temperatures is a deep-red liquid. It boils at 59° C., forming a deep-red vapor which is extremely irritating to the eyes and respiratory organs. Bromine does not occur as such in nature, but in combination with metals. The commercial source is magnesium bromide, which is associated with common salt and other chlorides in the deposits at Stassfurt, Germany, and in the brines of Michigan, Ohio, and West Virginia.[1]

The principal uses for bromine are as follows:

1. As bromides for medicinal and photographic purposes.
2. In other pharmaceutical products, such as monobromated camphor.
3. In dyestuffs, such as eosine and Hofmann's blue.
4. Miscellaneous chemical uses, such as an oxidizer in place of chlorine, a dissolving agent for gold, and in separating gold from platinum and silver.
5. In gas warfare, particularly in the tear-producing gases.

Four-fifths of the domestic production of bromine is made by an electrolytic process at the plant of the Dow Chemical Co., Midland, Mich., from Michigan bitterns. The remainder is produced by seven manufacturers of salt using Ohio bitterns, most of the plants being located in the Ohio valley. The largest of these firms is J. Q. Dickinson & Co., of Malden, W. Va. Production as a by-product of salt-making is by the acid-oxidizing process, and in each case is limited to a few hundred pounds per week.

The production of liquid bromine in the United States during 1920 has been very materially curtailed, due to the fact that German bromine and its derivatives have been imported in such quantities and at such prices that the existence of practically all American plants is said to be threatened. The output, according to the United States Geological Survey, was 1,160,584 lb., valued at $754,381, a decrease of 37 per cent. in quantity and nearly 40 per cent., in value from the output in 1919. The quantity produced, however, was greater than in any year before 1918.

The average price per pound received by the producers rose from 13 cts. in 1910 to $1.31 in 1916 and was 64 cts. in 1920, which is more than three times the average price in the year before the war. The New

[1] U. S. Geol. Surv.

York quotations on bulk bromine ranged from 70 to 90 cts. in the summer of 1920, but fell to 50 to 52 cts. in December.

During the last few years France has developed a source of bromine supply in Algiers or Tunis and will probably also be able to obtain bromine from the potash mines in Alsace. The German production is from bromides contained in the carnallite deposits at Stassfurt.

MARKETED PRODUCTION OF BROMINE IN THE UNITED STATES (a)

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Pounds.			*Pounds.*	
1906	1,283,250	$165,204	1914	576,991	$203,094
1907	1,379,496	195,281	1915	855,857	856,307
1908	760,023	73,783	1916	728,520	951,932
1909	569,725	57,600	1917	895,499	492,703
1910	245,437	31,684	1918	1,727,156	970,099
1911	651,541	110,902	1919	1,854,971	1,234,969
1912	647,200	145,805	1920	1,160,584	745,381
1913	572,400	115,436			

(a) U. S. Geological Survey.

No data for German and French production is available.

IODINE

Iodine at ordinary temperatures occurs as heavy violet to black crystals. It is used principally in the aniline color industry, in photography (as iodides), and in pharmaceutical products. No iodine is produced in the United States, although seaweed along the coast forms a possible source. Some iodine has been recovered from seaweed in other countries, particularly in Japan, where in 1917 the production amounted to 657,708 lb. of iodine and 308,640 lb. of potassium iodide. The most important source, however, is in the nitrate deposits in Chile, which are estimated to contain on the average 1 part of iodine to 1000 of sodium nitrate. The annual production amounts to about 1,500,000 lb. and this comes from more than 100 different producers. Resublimed iodine is quoted (December, 1920) at $5.40 per lb. The methods of production have been described in previous volumes of MINERAL INDUSTRY.

The imports of iodine into the United States are given in the following table:

Year.	Crude and Resublimed.	
	Pounds.	Value.
1913	240,045	$525,959
1914	463,333	951,308
1915	612,926	1,332,387
1916	2,033,068	5,158,265
1917	609,641	1,363,468
1918	407,333	843,302
1919	1,254,011	2,395,969
1920	293,941	593,672

CADMIUM

By A. T. Ward

Cadmium is a white metal of bluish tinge, having a specific gravity (cast) of 8.60. It melts at 320° C., and is easily separated from zinc by volatilization.

The principal sources of the American cadmium supply are as a by-product of the distillation of zinc, from bag-house or Cottrell-precipitator fume from certain copper and lead smelteries, and from the copper-cadmium precipitate produced in the solution-purification cycle of electrolytic zinc plants.

Cadmium is usually recovered and purified from zinc ores and blue-powder by fractional distillation. This method is used by the Grasselli Chemical Co. It is recovered from bag-house fume and the copper-cadmium precipitate by leaching with dilute sulphuric acid, purification of the solution, and electrolytic deposition of the cadmium. Variations of this method are used by the U. S. Smelting, Refining and Mining Co.[1] and the American Smelting and Refining Co.

Production is mainly in two forms—metal, and sulphide powder. The metal is used as follows:

1. Principally in low-fusing alloys employed in automatic sprinkler systems for fire protection.

2. In copper wire, where an alloy with from 0.5 to 1.2 per cent. Cd gives a product having the following properties: high tensile strength, increased annealing temperature, greater hardness and relatively high electrical conductivity (as compared with pure copper wire).

3. In cadmium-vapor arc lamps, where, when alloyed with gallium, it provides an intense monochromatic red-light source.[2]

4. Miscellaneous uses, such as: In testing storage-batteries; in lead bearing-metals; in solders (developed in Germany during the war period); and as a substitute for nickel as a rust preventative.

The sulphide is used principally in the paint, ceramic and glass industries, and it is believed that the pigment industry offers a still larger prospective field for the consumption of cadmium compounds. The manufacture of cadmium lithopone may be carried on in the same manner as zinc lithopone, but is not yet practiced commercially.[3]

[1] "Production of Electrolytic Cadmium," H. R. Hanley, *Chem. Met. Eng.*, Dec. 29, 1920.
[2] Scientific Paper of the Bureau of Standards, No. 371 (1920).
[3] "Advantages of Cadmium Lithopone," Paul W. Webster, *Chem. Met. Eng.*, Mar. 4, 1921 (communication).

Prices of the metal fluctuated as follows during 1920: first half, $1.45 to $1.50 per lb., dropping to $1.40 per lb. during the last half of the year. The sulphide sold during the same periods for respectively $1.50 per lb. and $1.25 to $1.35 per lb.

The production of cadmium in 1920 increased nearly 30 per cent., but there was also an increase in sales, which reached practically the record figure established in 1916, so that in 1920, as in 1919, the sales exceeded the output, and the stocks that yet remained from the large output in 1917–18 were notably reduced. The consumption of cadmium for the period 1916 to 1920, inclusive, as judged from the sales, has averaged about 127,000 lb. annually.[1]

PRODUCTION OF CADMIUM IN THE UNITED STATES (a)

Year.	Metal, Lb.	Value.	Sulphide, Lb.	Value.	Total Cadmium Content, Lb.	Total Value.
1913	54,198	$41,838	17,302	$12,136	67,650	$53,974
1914	91,409	81,205	22,723	20,241	109,076	101,446
1915	91 415	108,443	10,624	12,057	99,675	120,500
1916	135,212	210,931	22,176	27,942	152,453	238,873
1917	207,408	305,097	50,169	70,939	246,412	376,036
1918	127,164	188,203	51,702	70,315	167,440	258,518
1919	99,939	121,926	31,197	37,436	124,200	159,362
1920	129,283	151,261	32,133	37,274	154,290	188,535

(a) U. S. Geol. Surv.

The world's production of cadmium is practically all from the United States and Germany. A little is made at electrolytic zinc plants in England. Recent production in Germany is given as follows:[2]

Year.	Cadmium Metal, Pounds.	Average Price per Pound, Marks.
1913	81,993	3.28
1914	86,000	2.97
1915	82,000	2.92
1916	128,000	4.79
1917	172,000	6.74
1918	236,000	6.31
1919	85,395	16.51

[1] U. S. Geol. Surv.
[2] *Glückauf*, **56**, 818 (1920).

CEMENT

By Robert W. Lesley

The 100,000,000-bbl. mark in production which has been long aimed at by the manufacturers was reached in the year 1920. During the same period a marked advance in the price of cement was shown, the figure of $2.02 being the highest reached since 1881. With these two conditions obtained it would seem that of necessity the year 1920 would have been a red-letter one in the history of the Portland-cement industry, yet in looking over the year in retrospect it is doubtful if the producers secured even reasonable profits for the strenuous work done during the period in question. During the winter months there were continuous seasons of snow and ice, hampering production and transportation to an extraordinary degree, and when the spring business began to open in April a railroad strike covering the greater part of the country tied up mills and almost put a stop to shipments. As a result there was a great dearth of cars in June and July, so much so that in many of the eastern mills flat cars with canvas tarpaulins were used to convey the cement from mill to consumer. These conditions caused no little inconvenience to the manufacturer and great annoyance to the consumer and when the strike and the car shortage were over it was everyone's expectation that cement would be in abundance for the work offered.

The railroad strike, however, was succeeded by a coal shortage, and in July mills in the East were paying as high as $12.50 at the mines for coal, which in the early part of the year had been bought as low as $3.00. The result of all this was to make cement a very scarce commodity and to advance the price, while the manufacturers dealing with high coal and high labor were able to get little return from their investments. While the midsummer and autumn months of 1920 indicated a serious shortage in cement, as a matter of fact there were 115 plants in operation in that year as compared with 111 active plants in 1919, one additional works each having operated in the States of Alabama, Indiana, New York and Oregon; and in addition to this the productive capacity of the cement mills of the United States is estimated at between 130,000,000 and 140,000,000 bbl., so that the shortage which occurred, as above stated, was due to conditions extraneous to the producers themselves.

Table I gives the various hydraulic cements shipped in the years 1918, 1919, and 1920.

TABLE I.—PRINCIPAL HYDRAULIC CEMENTS SHIPPED FROM FACTORIES IN THE UNITED STATES. (a)

Class.	1918.		1919.		1920.	
	Quantity (Barrels).	Value.	Quantity (Barrels).	Value.	Quantity (Barrels).	Value.
Portland	70,915,508	$113,153,513	85,612,899	$146,734,844	96,311,719	$194,439,025
Natural, Puzzolan	432,966	401,341	528,589	583,554	767,481	1,150,890
Total	71,348,474	$113,554,854	86,141,488	$147,318,398	97,079,200	$195,589,915

(a) U. S. Geol. Surv.

Table II shows the Portland cement produced, shipped and in stock in the United States in 1919 and 1920 by districts.

Table III shows the Portland cement produced, shipped and in stock in the United States in 1919 and 1920 by states.

From Table V, which shows the statistics as to fuel used in burning cement, the large preponderance of coal as a fuel will be noted, and the figures show that relatively the same percentage of plants used coal as a fuel in 1920 as in 1919, the figures being 81.6 per cent. of the total in 1919 and 81.2 per cent. in 1920. There was a slight increase in the number of plants using crude oil, possibly due to the high prices and difficulty of obtaining coal.

As a result of the shortage, especially in certain parts of the country, the year 1920 shows a large increase in the number of barrels of cement imported into the United States, the figures being 498,036 bbl. valued at $1, 229,431, or $2.47 per bbl. This is a surprising figure when contrasted with the imports in 1918 of 302 bbl. and in 1919 of 8454 bbl. This increase of imports, however, is made up by a corresponding increase in exports, which during the same period amounted to 2,985,807 bbl. valued at $10,045,369, or $3.36 per bbl. The exports for the year exceeded those of 1919 by 522,118 bbl.

It is a matter of congratulation to note the increase in exports in the face of the cement shortage in the United States, proving, as it does, that the American manufacturers were determined to maintain the market which they had been establishing in foreign countries.

From the figures given it will be noted that the percentage of increase in quantity of barrels produced was 24 per cent., while the percentage of increase in shipments was 13 per cent., and that the average increase in factory price per barrel was 17½ per cent. So far as production is concerned the very large increases were in the districts covering the Far West and the Pacific Coast states, though New York, Illinois and western Indiana states also show considerable gain. Taking the districts in

TABLE II.—PORTLAND CEMENT PRODUCED, SHIPPED, AND IN STOCK IN THE UNITED STATES, BY DISTRICTS. (a)

Commercial District.	Production.							
	Active Plants.		Quantity (Barrels).		Percentage of Increase.	Stock (Barrels).		
	1919.	1920.	1919.	1920.		1919.	1920.	Percentage of Change.
Lehigh district (eastern Pennsylvania and western New Jersey)	20	20	22,747,956	25,417,804	+12	1,626,053	2,086,370	+28
New York	8	9	4,383,579	5,885,058	+34	721,304	553,989	−23
Ohio and western Pennsylvania	8	8	6,599,820	7,343,112	+11	347,292	752,582	+117
Michigan and northeastern Indiana	12	13	5,047,395	5,379,187	+ 7	273,641	727,927	+166
Kentucky and southern Indiana	3	3	2,490,497	3,293,090	+32	99,626	326,193	+227
Illinois and western Indiana	6	6	9,088,081	13,106,011	+44	322,190	1,094,358	+240
Maryland, Virginia, and West Virginia	4	4	2,469,768	3,044,691	+23	124,093	256,476	+107
Tennessee, Alabama, and Georgia	4	6	2,744,646	2,888,811	+ 5	37,235	191,319	+414
Iowa, Minnesota, and Missouri	10	10	10,038,625	12,406,745	+24	366,331	1,261,131	+244
Nebraska, Kansas, Oklahoma, and central Texas	15	15	6,151,095	8,177,245	+33	460,365	727,726	+58
Rocky Mountain States (Colorado, Utah, Montana, and western Texas)	8	8	2,811,843	3,764,502	+34	221,119	251,236	+14
Pacific Coast States (California, Oregon, and Washington)	13	15	6,204,630	9,316,989	+50	657,651	711,739	+ 8
	111	117	80,777,935	100,023,245	+24	5,256,900	8,941,046	+70

Commercial District.	Shipments.					Average Factory Price Per Barrel	
	1919.		1920.		Percentage of Change in Quantity.		
	Quantity (Barrels).	Value.	Quantity (Barrels).	Value.		1919.	1920
Lehigh district (eastern Pennsylvania and western New Jersey)	23,501,560	$38,511,273	24,953,127	$47,875,881	+ 6	$1.64	$1.92
New York	4,441,250	7,700,406	6,049,150	12,206,698	+36	1.73	2.02
Ohio and western Pennsylvania	7,102,442	12,144,272	6,943,400	13,414,249	− 2	1.71	1.93
Michigan and northeastern Indiana	5,459,439	9,274,025	4,922,329	11,892,249	−10	1.70	2.42
Kentucky and southern Indiana	2,640,556	4,405,939	3,069,407	6,248,406	+16	1.67	2.04
Illinois and western Indiana	9,932,158	16,092,758	12,321,840	22,561,398	+24	1.62	1.83
Maryland, Virginia, and West Virginia	2,613,963	4,517,591	2,912,308	6,128,117	+11	1.73	2.10
Tennessee, Alabama, and Georgia	2,830,588	4,952,245	2,730,420	6,010,436	− 4	1.75	2.20
Iowa, Minnesota, and Missouri	11,440,645	19,314,646	11,511,954	22,259,081	+ 1	1.69	1.93
Nebraska, Kansas, Oklahoma, and central Texas	6,309,024	11,662,504	7,900,247	17,110,729	+25	1.85	2.17
Rocky Mountain States (Colorado, Utah, Montana, and western Texas)	2,982,048	5,939,933	3,734,784	8,316,576	+25	1.99	2.23
Pacific Coast States (California, Oregon, and Washington)	6,359,226	12,219,252	9,262,753	20,415,205	+46	1.92	2.20
	85,612,899	$146,734,844	96,311,719	$194,439,025	+13	$1.71	$2.02

(a) E. F. Burchard, U. S. Geol. Surv.

TABLE III.—PORTLAND CEMENT PRODUCED, SHIPPED, AND IN STOCK IN THE UNITED STATES, BY STATES. (a)

State.	Production.							
	Active Plants.		Quantity (Barrels.)		Percentage of Increase.	Stock (Barrels).		Percentage of Change.
	1919.	1920.	1919.	1920.		1919.	1920.	
California	8	9	4,642,679	7,098,084	+53	430,003	463,930	+ 8
Illinois	4	4	4,206,918	5,538,558	+32	25,125	403,640	+1507
Indiana	5	6	7,262,454	10,787,751	+49	448,451	1,047,960	+ 134
Iowa	4	4	3,573,278	4,849,228	+36	126,162	553,607	+ 339
Kansas	7	7	2,927,270	4,340,794	+48	220,994	399,059	+ 81
Michigan	11	11	4,675,244	4,891,457	+ 5	219,641	666,071	+ 203
Missouri	5	5	5,216,347	6,017,517	+15	160,123	571,697	+ 257
New York	8	9	4,383,579	5,885,058	+34	721,304	553,989	− 23
Ohio	5	5	1,637,418	1,780,433	+ 9	82,468	197,521	+ 140
Oklahoma	3	3	1,362,687	1,553,652	+14	71,908	134,438	+ 87
Oregon and Washington	5	6	1,561,951	2,218,905	+42	227,648	247,809	+ 9
Pennsylvania	21	21	25,325,173	28,269,314	+12	1,781,997	2,388,836	+ 34
Texas	5	5	2,249,735	2,562,208	+14	205,918	143,502	− 30
Utah	3	3	819,861	1,093,741	+33	34,295	105,397	+ 207
Other States (b)	17	19	10,933,341	13,136,545	+20	500,863	1,063,590	+ 112
	111	117	80,777,935	100,023,245	+24	5,256,900	8,941,046	+ 70

State.	Shipments.					Average Factory Price Per Barrel.	
	1919.		1920.		Percentage of Change in Quantity.		
	Quantity (Barrels).	Value.	Quantity (Barrels).	Value.		1919.	1920.
California	4,743,336	$8,860,196	7,064,010	$15,449,645	+49	$1.87	$2.19
Illinois	4,873,831	7,901,689	5,148,040	10,012,158	+ 6	1.62	1.94
Indiana	7,667,976	12,527,770	10,191,126	18,649,115	+33	1.63	1.83
Iowa	4,569,110	7,798,347	4,421,783	8,742,854	− 3	1.71	1.98
Kansas	3,023,901	5,467,284	4,158,399	8,649,157	+38	1.81	2.08
Michigan	4,990,308	8,468,196	4,442,455	10,939,633	−11	1.70	2.46
Missouri	5,496,164	9,264,017	5,605,952	10,980,453	+ 2	1.69	1.96
New York	4,441,250	7,700,406	6,049,150	12,206,698	+36	1.73	2.02
Ohio	1,821,597	3,311,179	1,670,958	3,561,490	− 8	1.82	2.13
Oklahoma	1,366,884	2,657,339	1,484,698	3,284,412	+ 9	1.94	2.21
Oregon and Washington	1,615,890	3,359,056	2,198,743	4,965,560	+36	2.08	2.26
Pennsylvania	26,250,077	43,126,528	27,662,116	52,632,082	+ 5	1.64	1.90
Texas	2,318,747	4,226,222	2,626,130	5,898,972	+13	1.82	2.25
Utah	935,305	1,906,816	1,022,639	2,314,413	+ 9	2.04	2.26
Other States (b)	11,498,523	20,159,799	12,565,520	26,152,383	+ 9	1.75	2.08
	85,612,899	$146,734,844	96,311,719	$194,439,025	+13	$1.71	$2.02

(a) E. F. Burchard, U. S. Geol. Surv.
(b) Alabama, Colorado, Georgia, Kentucky, Maryland, Minnesota, Montana, Nebraska, New Jersey, Tennessee, Virginia, and West Virginia.

another way, it will be noted that the Lehigh district, comprising eastern Pennsylvania and western New Jersey, which has always been the largest single producer of cement, showed an increase of only 12 per cent. as compared with the general average increase of 24 per cent., and its share in the total of 100,000,000 bbl. was just about 25 per cent. as compared with figures in past years of nearly 30 per cent. of the total output of the country. The largest increases in price were shown in Michigan, the northeastern Indiana district, the Rocky Mountain and the Pacific Coast states, and Tennessee, Alabama and Georgia, where evidently the cement shortage was most acute.

Again the figures of production per capita show an increase, but are still below those for 1916. They are as follows:

Year.	Barrels.	Year.	Barrels.
1914	0.77	1918	0.64
1915	0.83	1919	0.78
1916	0.89	1920	0.84
1917	0.84		

Table IV shows the average price per barrel of Portland cement from 1870 to 1919, and it is interesting to note that the 1920 figures are the highest since 1881, when the American Portland-cement industry was just beginning to exist, and is slightly above the average of prices from 1883 to 1892, which marked the formative period in the industry when it was gradually fighting its way against European imports.

TABLE IV.—AVERAGE PRICE PER BARREL OF PORTLAND CEMENT, 1870–1920

1870–1880	$3.00	1896	$1.57	1909	$0.813
1881	2.50	1897	1.61	1910	0.891
1882	2.01	1898	1.62	1911	0.844
1883	2.15	1899	1.43	1912	0.813
1884	2.10	1900	1.09	1913	1.005
1885–1888	1.95	1901	0.99	1914	0.927
1889	1.67	1902	1.21	1915	0.860
1890	2.09	1903	1.24	1916	1.103
1891	2.13	1904	0.88	1917	1.354
1892	2.11	1905	0.94	1918	1.596
1893	1.91	1906	1.13	1919	1.690
1894	1.73	1907	1.11	1920	2.020
1895	1.60	1908	0.85		

TABLE V.—STATISTICS SHOWING FUEL USED IN BURNING PORTLAND CEMENT (a)

Fuel.	1919.				1920.			
	Number of Plants.	Number of Kilns.	Barrels.	Percentage of Total.	Number of Plants.	Number of Kilns.	Barrels.	Percentage of Total.
Coal	90	596	65,877,185	81.6	96	629	81,265,667	81.2
Coal and oil	3	32	6,985,271	8.6	1	24	6,676,029	6.7
Coal and gas	2	9			1	6		
Oil	14	73	6,634,775	8.2	16	79	9,495,798	9.5
Coal, oil and gas	1	5	1,280,704	1.6	2	9	2,585,751	2.6
Natural gas	1	5			1	6		
Total	111	720	80,777,935	100.0	117	753	100,023,245	100.0

(a) U. S. Geol. Surv.

TABLE VI.—IMPORTS OF FOREIGN CEMENT, IN BARRELS OF 380 LB.

1885	554,396	1897	2,090,924	1909	443,888
1886	915,255	1898	1,152,861	1910	306,863
1887	1,514,095	1899	2,108,388	1911	164,670
1888	1,835,504	1900	2,386,683	1912	68,503
1889	1,740,356	1901	939,330	1913	85,470
1890	1,940,186	1902	1,963,023	1914	120,906
1891	2,988,313	1903	2,251,969	1915	42,218
1892	2,440,654	1904	968,409	1916	1,836
1893	2,674,149	1905	896,845	1917	2,323
1894	2,638,107	1906	2,273,493	1918	302
1895	2,997,395	1907	2,033,438	1919	8,454
1896	2,989,507	1908	842,121	1920	498,036

TABLE VII.—EXPORTS OF CEMENT, IN BARRELS

Year.	Quantity.	Value.	Percentage of Total.	Year.	Quantity.	Value.	Percentage of Total.
1904	774,940	$1,104,086	2.4	1913	2,964,358	$4,270,666	3.2
1905	897,686	1,387,906	2.2	1914	2,140,197	3,088,809	2.4
1906	583,299	944,886	1.1	1915	2,565,031	3,361,451	3.0
1907	900,550	1,450,841	1.7	1916	2,563,976	3,828,231	2.7
1908	846,528	1,249,229	1.6	1917	2,586,215	5,328,536	2.8
1909	1,056,922	1,417,534	1.6	1918	2,252,446	5,912,166	3.2
1910	2,475,957	3,477,981	3.2	1919	2,463,573	7,513,389	2.9
1911	3,135,409	4,632,215	3.9	1920	2,985,807	10,045,369	3.0
1912	4,215,532	6,160,341	5.1				

Scientific Development

The Joint Committee on Specifications for Concrete and Reinforced Concrete held a number of meetings during the year and made material progress in the field of its work. Announcement was made at one of the late meetings that it was hoped that at the June, 1921, meeting of the American Society for Testing Materials a tentative specification dealing with this important subject would be ready to be presented.

The long discussed subject of fineness for Portland cement was finally brought to a conclusion as a result of numerous meetings between Government engineers and the committees having to do with specifications for Portland cement. As a result of this agreement the cement specification of the American Society for Testing Materials was finally put in form and in its finished state was adopted as one of the earliest standards of the American Engineering Standards Committee.

In connection with cement specifications it is to be noted that during the year new specifications were issued by the English Standards Committee (consisting of representatives of the Government and the various engineering societies of England), and by the Japanese Government through its Departments of Agriculture and Commerce.

The year was also marked by important investigations conducted by the engineering societies and individual engineers in the field of concrete and reinforced concrete, and especially in the field of aggregates and

requisite amounts of water required to produce ideal concrete mixtures. In this field much interesting work was done by the Lewis Institute of Chicago in connection with the laboratory of the Portland Cement Association, under the direction of Dr. Duff A. Abrams.

With the cessation of war conditions and the constant demand for new ships, the construction of concrete ships, barges, etc., dwindled away into nothing, and while in Europe there is still some work being done in this field production has practically ended for the present in the United States.

A similar statement may be made in connection with the production of potash as a by-product of cement manufacture. The closing of German importations, owing to war conditions, had a tendency to develop a demand at very high prices in this country for potash. This was met during the war times by several cement manufacturers who equipped themselves for the recovery of the potash to be found in the cement dust going up from the kiln stacks. By the use of the Cottrell and other methods of dust recovery a considerable amount of potash was obtained, which was marketed at prices from $300 to $400 per ton, and at least one mill, which was earliest in the field, produced a very handsome income by the recovery of this by-product. Since the German and French competition has begun again, the price of potash has dropped so that there is little to be gained in this field in the cement industry at present, though in some cases the existing machinery is used for the recovery of dust hitherto going up through the stacks.

Much good work was done during the year in connection with various methods of economical cement manufacture, and owing to the particular attention that was called to the fuel question by the great advance in coal prices much of this work was in the field of coal economy. Many additional waste-heat boilers were installed for the use of kiln gases in steam production, while other interesting researches were made in the direction of lessening the radiation from the rotary kilns and in saving the heat going out with the hot clinker with the cooling.

Concrete construction of houses was a marked feature of the year 1920 both in this country and in England. Over 3500 concrete houses were erected in England by private persons with the aid of Government housing subsidies, while in the United States numerous industrial establishments in various parts of the country adopted concrete as a material for their housing operations and hundreds of houses of this type were constructed.

An important feature of the year was the great increase in appropriations for concrete roads, and the increasingly successful development of this form of highway. As a result it may be stated that great improve-

ments in road making, so far as scientific and economical construction are concerned, were made.

While the year was marked by several cement mergers and by the broadening of the field of some of the larger companies through the purchase of additional plants, it was also marked by legislation in many states authorizing the construction of Portland cement works with state funds. Several of these were planned during the year and it is expected that in 1921 funds would be provided and construction begun, though in some of the states considerable opposition was manifested to the plans proposed.

Cement Activities in Foreign Fields

Argentina.—The plant of the Compania Argentina de Cimento Portland, which is operated by the International Portland Cement Co. of New York, is located in the heart of the province of Buenos Aires at a distance of about 8 hr. by train from the latter city. It has a capacity of 3000 bbl. a day and uses petroleum as a fuel.

Austria.—In consequence of more plentiful fuel the Austrian cement industry has been able to increase production for 1920 by approximately 20 per cent. The output for the year will amount to 120,000 or possibly 130,000 tons. This is far below the capacity of the industry and only about 22 per cent. of the normal needs of the region now comprised within Austria. It is expected that exporting will be resumed, at least to some extent, during 1921.

Belgium.—Reconstruction work in Belgium and in Northern France has made such large demands for cement that there is none to export. Owing to the war the capacity of the mills has been reduced by the destruction and dismantling of plants from 250,000 to 500,000 bbl. per month, and the Associated Belgian Portland Cement Manufacturers, embracing 14 plants, expect that there will be little or no Belgian cement for export before the spring of 1921.

Canada.—The Canada Cement Co. in its report for 1920 shows that only 3.1 per cent. was earned applicable to the $13,500,000 common stock, against the 6 per cent. distributed, with the result that after the dividends and reserves there was a deficit of $525,885, which reduced the general surplus to $898,972. Net for 1920 was $2,362,742, against $3,057,553 in 1919.

Coal last year was 540 per cent. more than in 1914 and labor advanced 145 per cent. The average price of all commodities entering into the manufacture advanced 196 per cent. and the selling price advanced only 90 per cent.

Chile.—It is reported that a company called the Arica Cement Co. is to build a cement works in Chile near the port of Arica. A capacity of 150,000 bbl. of cement per annum is proposed, and a capital of $1,000,000 is being raised for the purpose.

China.—A Chinese cement company located at Tong-shan, Chihli Province, on the Peking-Mukden Railway, controls the cement industry of North China. The factory was established in 1906 and is equipped with modern machinery. Limestone exists on the site of the works. The product is gray Portland (no white), and both wet and dry processes are used, with large rotary kilns. The normal output is 600,000 bbl. per annum, but in 1918 the output was 800,000 bbl. Foreign markets have principally been Java and the Philippine Islands, and locally the product is mostly used by the railways and mines.

England.—Since the war the English industry has had a period of good shipments at high prices. It suffered in 1920 from continuing advances in coal prices accompanied by a constant falling off in the quality, caused by careless mining and screening which gave much waste in the fuel delivered.

The English exports before and since the war are given below.

	Quantity, Long Tons.	Value, F.o.b.	Average Value Per Ton. s.	d.
1913.....	747,736	£1,273,080	34	6
1919.....	385,526	2,050,336	106	4
1920:				
Jan.—March ...	130,771	713,370	109	1
April—June.....	149,770	848,547	113	4
July—Sept.....	174,055	1,078,847	124	0

The increase in exports has been accompanied by a very substantial increase in output.

Much progress has been made in the work of the British Portland Cement Research Association, an organization embracing the leading scientists of the industry and modeled in a general way upon the technical section of the American Portland Cement Association.

Esthonia and Livonia.—The Riga Cement Factory in Livonia employs 1500 men and has a capital of 2,250,000 rubles, while two plants in Esthonia employ 1500 men and have a combined capital of 5,000,000 rubles.

Finland.—There are two Portland-cement factories in Finland. One of them, the Pargas, Kalkbergs Aktie-Bolag, located at Pargas, has a joint-stock capital which was increased in 1919 from 10,000,000 marks to 15,000,000 marks and has a production capacity of 450,000 bbl. a year, with machinery capable of increasing this to 900,000 bbl. a year. The other factory is the Lojo Kalkverks Aktie-Bolag located at Lojo. It has a joint-stock capital of 3,800,000 marks and a production capacity of 225,000 bbl. per annum, which will soon be doubled. Besides making

cement, both of these companies carry on the breaking of limestone and the manufacturing of lime, most of which has been used by the cellulose factories, the sales for agricultural use having been insignificant.

During the year 1919 the cement factories in Finland worked only for home consumption and the sales were small because of the limited building activity. No cement or lime was exported, as such export was prohibited, but some cement was imported from Esthonia.

France.—Reconstruction work in the devastated regions has kept French cement manufacturers busy in 1920. While there have been but few new plants put in operation, much work has been done in the way of improving and reconstructing the existing ones. Continuous automatic vertical kilns have been added in some cases, and in the great La Farge works a molten-clinker process has been introduced.

French Indo-China.—The Portland-cement works at Haiphong have been very busy during the war and have a capacity of 125,000 bbl. annually, which it is proposed to increase to meet growing demands for Portland cement in the Orient. This increase will be 60,000 tons annually.

Germany.—Government operation of the German cement industry, put into effect on Jan. 1, 1917, was provisionally dispensed with on July 27, 1920, and manufacturers resumed control of their plants.

The price of cement in Germany at the outbreak of the war was 35 marks per ton for both Government and private contracts. Following the establishment of Government operation of the cement industry and the accompanying official regulation of prices there was a rapid rise in the cost of this commodity. The following prices per ton (f.o.b. mill and exclusive of packing) show the course of these prices since 1914:

Periods.	On Government Contracts. Marks.	On Private Contracts. Marks.
Aug. 1, 1914	35	35
Jan. 1, 1917	43	43
Oct. 1, 1918	73	76
Apr. 1, 1919	88	91
Apr. 1, 1920	390	406
Aug. 1, 1920	333	340

During the middle of last summer the production of cement was somewhat increased, due in part to the resumption of operations by the Offenbacher Portland-Zementfabrik (Gruppe der Portland-Zementwerke, Heidelberg-Mannheim-Stuttgart) after lying idle for a period of more than five years. The cement industry in Germany has not felt the effect of the coal shortage as much as other lines of manufacture for the reason that the mills were, to a considerable extent, able to use low-grade coal. Germany has resumed the shipment of cement to foreign markets.

Coal and car shortage have caused considerable trouble for the manu-

facturers, but in some foreign markets German cements are already beginning to appear, indicating that some of the prevailing difficulties have to some extent been overcome.

India.—It is reported that a new cement factory, capitalized at $650,000, is to be erected at Beleli, a station on the Northwestern Railway, which is 8 miles from Quetta, the capital city of Baluchistan.

Jamaica.—A Portland cement works is being planned for the Island by an English syndicate, to use the available materials for the manufacture of a high-class cement. It is expected it will be used in Jamaica itself for railroad and other works and the surplus product exported to the neighboring countries of South America.

Japan.—The following figures, in barrels, will give some idea of the increase in production of Portland cement in Japan and of the demand of the export trade for the Japanese product.

	Output.	Export.	Export to Colonies
1913	3,741,000	149,000	147,000
1914	3,625,000	258,000	174,000
1915	3,943,000	677,000	253,000
1916	4,495,000	674,000	268,000
1917	5,501,000	533,000	382,000
1918	5,960,000	900,000	264,000
1919	6,500,000	997,000	258,000

As will be seen from the above table, the export of cement for 1913, or the year preceding the outbreak of war, occupied only 4 per cent. of the entire production. But the volume of export increased to 258,000 bbl. in 1914, in which year the war broke out, 677,000 bbl. in 1915, and little less than 1,000,000 in 1919, or over 15 per cent. This tremendous increase in the export of cement since the war is due to the fact that as the war progressed, the belligerents in Europe became unable to continue to meet the demands in the South Seas, India and Australia and other large consumers of cement, as they were compelled to devote their energies to the manufacture of war materials. As for the export to the colonies, it has also been yearly increasing, Korea being the largest consumer.

The enormous increase in demands for cement material brought the price up to a considerable extent, increasing it about 3 yen per bbl. in pre-war days to as much as 17 yen per bbl. in March and April of 1920. From the effect of the financial convulsion the prices since then have gone down as low as 12 to 13 yen.

There are twelve principal cement works in the country, whose capacity has increased from 32,000,000 yen in 1914 to 44,600,000 yen at the end of 1920.

Jugo-Slavia.—There are six cement factories in Dalmatia with a production of about 500,000 tons per year, principally controlled by Italian capitalists. They have been paying good dividends since they

started producing in 1919—25 to 40 per cent. The rest of Serbia has five factories producing an additional 500,000 tons. At the present time there are several English capitalists who are conducting negotiations for the purchase of the largest of these factories.

For the Portland-cement industry the ideal location is Dalmatia, because the raw material is located not 100 yd. from the shore, so that Italian factories are importing raw material over the Adriatic Sea.

Dalmatian cement is known very favorably in South America and the Near East, where it was exported before the war. The cement would cost less than $4 per ton. Native labor is available at low rates, in view of the exchange, and lumber for barrels is also cheap.

New South Wales.—The production of Portland cement in 1920 amounted to 143,887 long tons, an increase of 8046 tons over the preceding year.

Poland.—Poland's normal output of 1,750,000 bbl. has been reduced about 20 per cent. by the war. Owing to car shortage shipments have been held up and stockhouses are reported to be filled with cement.

Spain.—Of the 401,017 tons of cement produced in Spain in 1918, 186,713 tons was natural cement proceeding from 44 plants, 10 of which were in the Province of Barcelona, 10 in the Province of Gerona, and 9 in the Balearic Islands. The cement works of the Province of Barcelona yielded 86,730 tons of the total of 214,304 tons of Portland cement produced during 1918.

By a recent royal order cement is made dutiable for both import and export.

Switzerland.—The year 1920 was a bad one for the Swiss cement industry, as capital was timid about engaging in building enterprises and little construction was done. No success attended the efforts of Swiss manufacturers to penetrate peacefully the German and French markets, and in the face of large reduction in price the output was barely 52 per cent. of the manufacturing capacity.

Tasmania.—A Portland-cement works will be projected on Maria Island, off the east coast of Tasmania, where cement-making materials are found in abundance. The capital is from one to one and a half million dollars and it is estimated that the output will reach from 30 to 50 tons when the plant is completed.

Uruguay.—The International Portland Cement Co. of New York operates a large plant in the city of Montevideo in the Republic of Uruguay.

CHROMIUM

By Samuel H. Dolbear

The production of chromite in the United States in 1920 decreased in both quantity and value per ton as compared with 1919. But 2502 tons were mined and shipped as against 5079 tons in 1919, a decrease of about 50 per cent. in amount, while the value per ton fell from $26 to about $18, a drop of about one-third.

Imports

Importations, on the other hand, increased from 61,404 long tons in 1919 to 150,275 tons in 1920. This does not, however, accurately represent the increase in consumption of the ore in these two years, for consumers held large stocks at the beginning of 1919, and these were largely drawn upon during the year. One concern alone is reported to have held over 50,000 tons at its plant in December of 1918.

Of the imports, 71 per cent. came from Rhodesia and New Caledonia. Rhodesia was by far the more important source, its shipments to the United States amounting to 74,152 tons, while there were received from New Caledonia but 32,543 tons.

Prices

Prices of imported chromite quoted in the technical press ranged from 72 to 80 cts. per long-ton unit of one per cent. of chromic oxide (Cr_2O_3) in May, to 55 to 60 cts. in December. The declared value of 150,275 tons imported in 1920 was $1,921,824, equal to $12.79 per ton. There appears to be a glaring discrepancy between this figure and the value quoted in the technical journals. If the imports averaged but 40 per cent. chromic oxide and were worth 55 cts. a unit, the lowest figure quoted, the price would be $22 a ton, or nearly twice the declared value.

PRODUCTION OF CHROMITE IN THE UNITED STATES

Year.	Quantity, (Long Tons).	Value.
1910	205	$2,729
1911	120	1,629
1912	201	2,753
1913	255	2,854
1914	591	8,715
1915	3,281	36,744
1916	47,035	726,243
1917	43,725	1,049,400
1918	82,430	3,937,991
1919	5,079	129,302
1920	2,502	44,857

CHROMIC IRON IMPORTED INTO THE UNITED STATES, 1916–1920, IN LONG TONS (a)

	1916.	1917.	1918.	1919.	1920.
Cuba	34	17	8,821	14,461	710
Canada	12,220	19,012	20,949	8,941	8,491
Brazil	.....	.....	17,854	4,800	239
Greece	7,900	.....	.....	.....	5,302
Spain	.....	.....	.....	3,035	40
French Oceania	(b)30,950	10,300	25,761	7,125	56,682
Australia and New Zealand	(b) 2,968	.....	15,976	13,854	(b)2,778
British South Africa	(c)23,000	4,750	...521	29	(c)39,400
Portuguese Africa	(c)38,850	37,800	8,000	4,000	11,000
Turkey in Asia	.....	.....	.....	3,500	12,760
Guatemala	.....	179	1,193	1,659	1,122
Total	115,945	72,063	(d)100,142	61,404	(d)150,275

(a) Statistics furnished by the Department of Commerce, Bureau of Foreign and Domestic Commerce. (b) E. J. Lavino & Co. importers, credit New Caledonia with all that listed above under French Oceania and Australia. (c) E. J. Lavino & Co., importers, credit Rhodesia with all that listed above under British South Africa and Portuguese Africa. (d) Includes other countries.

Mining and Production

Asia Minor.—No heavy movement was reported from this country during the year, although the stocks on hand at the beginning of the year were reported to be fairly heavy, amounting to more than 35,000 tons. This ore is probably relatively low-grade material remaining from war-time operations when the deposits were worked by German interests. It has been the policy of the Turkish Government for many years to prevent these deposits from falling into foreign hands, but a precedent was established during the war when some of the mines were sold to the Krupps and others, and in 1920 firmans or concessions were granted covering two deposits, these being taken by British subjects. Furthermore, three of the largest mines at Macri, on the coast of Asia Minor opposite the Isle of Rhodes, are operated by Lane, Raggio & Co., Inc., an American corporation. Of 25,000 tons normally produced, 5000 tons is shipped to Europe, the remainder going to America.

Bosnia.—Chrome deposits located at Dubostica, Bosnia, were first opened in 1884. During the war 200 men were employed in these deposits by the Austrian Government, producing about 2000 tons a month. The mines are now operated by the Jugo-Slav Government, which is continuing to drive a tunnel started by the Austrian Government.

Canada.—Shipments of chrome ore and concentrates from the eastern townships of the Province of Quebec were about 2000 tons greater in 1920 than in the previous year. No shipments were reported from British Columbia. The total shipments of ores and concentrates were 10,500 short tons valued at $244,984, which included 2579 tons of ore averaging about 40 per cent. Cr_2O_3, valued at $73,100, and 7921 tons of concentrates averaging about 49.9 per cent. Cr_2O_3, valued at $172,884. The total Cr_2O_3 content was about 4961 tons. Of the total shipments 1436 tons was sold in Canada and 9064 tons sold for export.

The exports of chromite according to the trade reports were 8431 tons valued at $151,456, or an average of $21.89 per ton, as compared with exports in 1919 of 9078 tons valued at $198,733, or an average of $21.89 per ton.

There has been no recent production of ferrochromium in Canada. Some small quantities have been imported of which there is no separate record.[1]

Production of ore was confined chiefly to the Mutual Chemical Co. and the J. V. Belanger interests, with the Black Lake Asbestos and Chrome Co.

Costa Rica.—The deposits of this country, which are operated by interests allied to the United Fruit Co., shipped high-grade ore to the United States during the year. It is planned to increase production.

Cuba.—The chrome mines in Cuba were developed during the war by the Bethlehem Steel Co., and continued to ship some ore during 1920.

New Caledonia.—The Chrome Co., Ltd., of London controls the Tielbaghi Chrome Mines near Port Pagouméne. Its production in 1920 was 30,303 metric tons, a slight increase over the 27,382 tons sold in 1919. The company has contracted large amounts for future delivery.

Exhaustion of some of the deposits has been reported and others are being intensively developed.

Rhodesia.—This country is the most important producer of chromite, its yield since 1908, when production first began, to the close of 1920 being 665,049 tons. Shipments to the United States during the year amounted to 74,152 tons. The operating mines are located chiefly at Selukwe, although important deposits also occur at Makico and Lomagundi.

Newly discovered deposits in Southern Rhodesia are being mined by the United Chrome Prospecting Syndicate, Ltd., which controls a large area of chromite-bearing formation.

In the Selukwe district the chief operators are the Rhodesian Chrome Mines, Ltd., and the Rhodesian Metals Syndicate. These mines have railway facilities.

United States.—Production in the United States in 1920 was about one-half of that of the previous year. Of a total of 2502 tons valued at $44,857, California mines yielded about 1400 tons and those of Oregon 1100 tons. A small amount of ore was mined in Montana and Maryland, but none was shipped.

Most of the domestic production was used on the Pacific Coast, and was sold for about $25 a ton for ore containing 40 to 45 per cent. chromic

[1] Prelim. Rept. Min. Prod. of Canada, 1920, Can. Dept. of Mines.

oxide. Much of the product is shipped as concentrates. Nineteen mines shipped ore during the year, 17 located in California, one in Oregon and one in Wyoming.

THE PRINCIPAL SUPPLIES OF CHROME ORE (a)
(In metric tons)

	1912.	1913.	1914.	1915.	1916.	1917.	1918.(c)	1919.	1920.(c)
Brazil	.....	.....	.....	.....	.....	.....	18,141	4,877	3,451
Bosnia	200	305	533	.....	.....	.....	500	.....	.....
Canada	.....	.....	123	11,196	24,963	32,978	19,953	8,678	9,525
Cuba	.....	.....	.....	.....	.....	.....	9,000	14,461	710
Greece	6,468	6,342	7,059	10,420	9,880	6,750	2,640	4,164	.....
Guatemala	.....	.....	.....	.....	.....	2,000	1,200	659	.....
India	2,936	5,670	5,986	3,828	20,484	27,497	58,670	37,026	.....
Japan	.....	.....	2,108	2,979	8,280	8,939	6,247	4,158	.....
New Caledonia (b)	51,516	63,370	42,000	67,000	74,115	41,892	26,000	32,543	60,000
Queensland	.....	.....	.....	.....	.....	768	236	.....	161
Rhodesia	62,850	63,384	49,009	61,590	80,624	74,133	31,789	35,850	61,239
Russia	21,277	.....	.....	.....	.....	.....	16,000	.....	.....
Turkey	.....	26,374	.....	.....	.....	.....	14,000	3,500	25,000
United States	204	259	601	3,336	47,791	44,429	83,753	5,161	2,542

(a) From the official reports of the respective countries. (b) Exports, except 1909, 1910, 1914 and 1915. (c) Estimated in part.

Chromium Compounds

The quantity and value of imports of chrome yellow or green are given in the following table:

Year.	Quantity, Pounds.	Value.
1912	156,733	$25,516
1913	161,153	24,731
1914	154,933	24,922
1915	48,303	9,492
1916	29,495	6,099
1917	18,536	2,420
1918	37	10
1919	250	35

CHROMATE AND BICHROMATE OF POTASH, CHROMIC ACID, AND CHROME ORE IMPORTED AND ENTERED FOR CONSUMPTION IN THE UNITED STATES (a)

Year.	Chromate and Bichromate of Potash.		Chromic Acid.		Chrome Ore.		Total Value.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	
	Pounds.		Pounds.		Long Tons.		
1913	18,629	$1,819	5,562	$1,100	65,180	$622,821	$625,740
1914	31,858	2,375	9,164	1,597	74,686	655,306	659,278
1915	32,942	2,902	3,571	755	76,455	780,061	783,718
1916	459	75	*Nil.*	*Nil.*	115,886	1,548,402	1,548,477
1917	2,404	962	*Nil.*	*Nil.*	72,063	1,110,659	1,111,621
1918	20	8	9,512	1,857	100,224	2,892,825	2,894,690
1919	15,450	4,271	*Nil.*	*Nil.*	61,404	1,381,497	1,386,678
1920	4,414	2,690	1,100	90	150,275	1,921,824	1,924,604

(a) Bureau of Foreign and Domestic Commerce.

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COAL AND COKE[1]

By Frank H. Kneeland

Production of bituminous coal in the United States in 1920 is estimated at 556,500,000 net tons, an increase compared with 1919 of 98,000,000 tons, or 21 per cent. Production of anthracite is estimated at 89,000,000 net tons, an increase of 1,000,000 tons, or 1.1 per cent. The production of bituminous coal has been exceeded in but one previous year, 1918, when the total output was 579,000,000 tons. The best pre-war year was 1913, in which 478,000,000 net tons of bituminous coal was produced. In 1917, when the production was 551,000,000 tons, the third highest record was attained.

In point of value at the mine the year 1920 set a new record. Official figures of the value of the bituminous coal produced in 1918 are $1,491,000,000, compared with which it is conservatively estimated that the smaller production in 1920 netted the producers approximately $2,225,000,000. Of the increase in value at the mine mouth of $734,000,000, it is estimated that the miners and mine laborers received $234,000,000 as wages and bonuses.

Although production of bituminous coal in the United States in 1920 increased 21 per cent. over 1919, all producing fields did not share equally in the gain. Considering the coal fields by groups, we find that the Middle West—Illinois, Indiana and western Kentucky—made the largest gain, 38 per cent. The increase in quantity was 36,400,000 tons, exceeded only by that in the middle and northern Appalachian territory. This large region, comprising the coal fields of Pennsylvania, Ohio, West Virginia, Virginia, Maryland, Michigan and eastern Kentucky, produced in 1920 332,148,000 net tons of bituminous coal, a gain over the previous year of 43,837,000 tons, or 15 per cent.

The Southern states of Tennessee and Alabama produced 25,178,000 tons in 1920, compared with 20,380,000 tons in 1919, an increase of 22.5 per cent. The Western Interior region, comprising the fields from Iowa to Texas, had an estimated output of 29,707,000 net tons, a gain over the previous year of 27 per cent. In the Far West the Rocky Mountain region, including the fields of Montana, Wyoming, Colorado, New Mexico and Utah, registered a gain of 22.6 per cent. over 1919 and Washington had a small increase of 234,000 tons, or less than 1 per cent.

[1] Material on coal in the United States abstracted from *Coal Age*.

PRODUCTION OF COAL IN THE UNITED STATES IN SHORT TONS. (a)

State.	1917.	1918.	1919.	1920.
	Quantity.	Quantity.	Quantity(e)	Quantity(e)
Alabama	20,068,074	19,184,962	15,230,000	16,700,000
Alaska	53,955	75,606	53,000	68,000
Arkansas	2,143,579	2,227,369	1,680,000	2,310,000
California and Idaho	6,423	6,400	(b)	(b)
Colorado	12,483,336	12,407,571	10,100,000	12,100,000
Georgia and North Carolina	119,028	68,136	(c)100,000	(c)125,000
Illinois	86,199,387	89,291,105	64,600,000	90,050,000
Indiana	26,539,329	30,678,634	20,912,288	30,420,000
Iowa	8,965,830	8,192,195	6,300,000	9,170,000
Kansas	7,184,975	7,561,947	5,750,000	6,700,000
Kentucky	27,807,971	31,612,617	28,500,000	31,000,000
Maryland	4,745,924	4,497,297	3,021,686	4,050,000
Michigan	1,374,805	1,464,818	996,545	1,440,000
Missouri	5,670,549	5,667,733	4,060,000	5,750,000
Montana	4,226,689	4,532,505	3,236,369	4,440,000
New Mexico	4,000,527	4,023,239	3,170,000	3,750,000
North Dakota	790,548	719,733	840,959	770,000
Ohio	40,748,734	45,812,943	39,050,000	45,000,000
Oklahoma	4,386,844	4,813,447	3,200,000	4,200,000
Oregon	28,327	13,328	(b)	(b)
Pennsylvania, bituminous	172,448,142	178,550,741	145,300,000	163,000,000
South Dakota	8,042	7,942	(b)	(b)
Tennessee	6,194,221	6,831,048	5,150,000	6,750,000
Texas	2,335,815	2,261,135	1,600,000	1,800,000
Utah	4,125,230	5,136,825	4,570,000	5,870,000
Virginia	10,087,091	10,289,808	9,500,000	9,850,000
Washington	4,009,902	4,082,212	2,990,447	3,750,000
West Virginia	86,441,667	89,935,839	79,036,553	87,500,000
Wyoming	8,575,619	9,438,688	7,100,000	10,000,000
Total bituminous	551,790,563	579,385,820	458,063,000	556,563,000
Pennsylvania, anthracite	99,611,811	98,826,084	88,092,000	89,100,000
Grand total	651,402,374	678,211,904	546,155,000	64 5,663,00

(a) U. S. Geol. Surv. (b) Included with Georgia. (c) Includes minor production from other states. (e) Estimated.

ANNUAL PRODUCTION OF THE UNITED STATES, 1913–1920
(Net tons)

Year.	Pennsylvania Anthracite.	Bituminous.	Total.
1913	91,525,000	478,435,000	569,960,000
1914	90,821,000	422,704,000	513,525,000
1915	88,995,000	422,624,000	531,619,000
1916	87,578,000	502,520,000	590,098,000
1917	99,612,000	551,790,000	651,402,000
1918	98,826,000	579,386,000	678,212,000
1919[1]	88,092,000	458,063,000	546,155,000
1920[1]	89,100,000	556,563,000	645,663,000

[1] Estimated.

PRODUCTION OF BITUMINOUS COAL AND LIGNITE IN THE UNITED STATES WITH ESTIMATES FOR 1920, BY MONTHS, IN NET TONS

	1917.	1918.	1919.	1920.
January	47,967,354	42,227,000	41,487,000	48,689,000
February	41,352,711	43,777,000	31,566,000	40,181,000
March	47,868,652	48,113,000	33,719,000	46,832,000
April	41,854,320	46,041,000	32,164,000	37,939,000
May	47,086,452	50,443,000	37,547,000	38,993,000
June	46,824,646	51,138,000	37,054,000	45,114,000
July	46,291,572	54,971,000	42,698,000	45,009,000
August	47,372,226	55,114,000	42,883,000	48,910,000
September	45,107,956	51,183,000	47,402,000	49,172,000
October	48,337,726	52,300,000	56,243,000	52,144,000
November	47,689,801	43,895,000	18,688,000	51,457,000
December	44,037,147	40,184,000	36,612,000	52,123,000
Total	551,790,563	579,386,000	458,063,000	556,563,000

Illinois, according to the preliminary figures of the Geological Survey, in 1920 reached the goal for which she has been striving for years, namely to replace West Virginia as the second largest coal-producing state in the Union. West Virginia's output increased only about 10,000,000 net tons over 1919, while Illinois gained nearly 25,000,000 tons.

The middle and northern Appalachian region fell short by 20,000,000 tons, or nearly 6 per cent., of the high mark set in the war year of 1918. Illinois, Indiana, and western Kentucky had a production in 1920 equal to that in 1918, and the South and West fell little short of reaching the war maximum. As was so clearly demonstrated in the war years, it is in the immense coal fields of the East that greatest difficulty is experienced in meeting large demands for increased production.

The rate of bituminous coal production in 1920 may be roughly described as having dropped from the high point of the first half of the

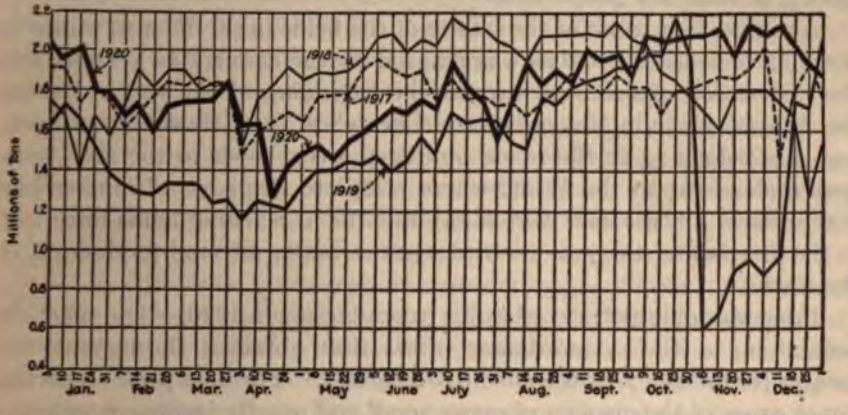

FIG. 1.—Estimated average production of bituminous coal per working day, 1917–1920.

year, attained the first week of January, to the low point of the year in the middle of April, and from then on until the holiday season at the end of 1920 to have climbed upward, with many backslidings on the way. From Oct. 1 on the rate of production was, with the exception of the highest of all records, in the week preceding the miners' strike in November, 1919, greater than for the same period in any other year for which records are available. For the last thirteen weeks of 1920 production averaged well above 12,000,000 net tons a week, a record of sustained output equaled only during the summer and early fall of 1918, when every energy of the country seemed to be directed toward getting out coal and still more coal.

From the first week of January until the middle of December car-shortage was the principal factor limiting production of bituminous coal.

That is to say, each week of this period the demand for coal was in excess of the ability of the railroads to carry it from the mines. To a limited extent labor trouble adversely affected output, particularly in Alabama and West Virginia, where strikes were in effect throughout the greater part of the time, and in Illinois, Indiana, Ohio and central Pennsylvania, where there were temporary losses because of local strikes during the summer. These strikes, however, cannot be said to have decreased the production of the country as a whole, for when the mines at which the men were on strike did not operate, the cars were in use elsewhere. Likewise the mines that reported no market as a cause of non-operation in the last half of December were those properties which, because of high cost of production, were not in position to compete with lower-cost operations after prices fell to low levels. It is not at all unlikely that the total output was as great as it would have been in any event, despite the closing of these few properties.

An important cause of the failure of the fields in the East to attain as great an increase in 1920 as was realized by the country as a whole was the dislocation of open-top cars at the beginning of the year. During the miners' strike in November and December, 1919, thousands of open-top cars belonging to the roads serving the coal fields in the East were sent under load to the West, where complete stoppage of mining had taken place. These cars were many months in reaching home lines and in the first half of the year their absence seriously affected production in the East.

Price was an important stimulus to production in 1920. The effect on production of the extraordinary prices that obtained throughout the greater part of the year is difficult to appraise. The high prices were the direct cause of the opening of many small and usually inefficient mines—inefficient both in the use of labor and of transportation. An equal or a greater output could doubtless have been obtained from a smaller number of mines working with the same total number of men and railroad cars. But it is equally evident that had it not been for the high prices there would not have been the nationwide interest in efforts to make the supply of transportation carry more coal. It was recognized by all that the cure for high prices was more tons of coal. Had it not been for the evidence of tremendous demand afforded by the high price of coal, it is doubtful whether the Interstate Commerce Commission would have given absolute priority to coal in the use of that transportation.

Thousands of new coal mines were opened in 1920, but for the most part they have again closed. How much of the tonnage that was loaded and that figures in the statistics as coal actually was slate and dirt will never be known, but, as in 1917 and 1918, it is certain that the percentage

was appreciable and that the total transportation wasted in hauling rock was a national loss. To this the smaller new operations were the heaviest contributors because they were in most instances "outcrop" mines and were not equipped to clean their product.

Of the service orders of the Interstate Commerce Commission, those re-locating open-top cars—bringing the wanderers in the West back home in the East— ordering increased shipments to the Lakes and, of greater importance, those giving coal preferential use of open-top cars, were potent in increasing the production of soft coal. The Lake priority orders increased production because they provided for a shuttle movement between the mines and Lake Erie ports and thereby decreased car detention and provided potentially more cars for loading coal.

DISTRIBUTION

Four different conditions affecting the distribution of bituminous coal may be roughly assigned to the four quarters of 1920. The first quarter was devoted to filling the gaps in supply left by the miners' strike of the previous year, the second quarter saw tremendous demand for free coal and every possible ton going to the highest bidder, followed by three months in which prices and distribution were brought more nearly into balance, while finally in the last quarter of the year, supply having caught up with demand and fears of a shortage having been allayed, a pronounced drop in prices and to a small extent in production took place.

It is of primary importance in considering the subject of distribution of coal to have clearly in mind the difference between distribution as to sections of the country—that is, geographic distribution—and among classes of consumers—use distribution. The problems of furnishing coal to New England and the Northwest are examples of the first class and the problem of getting coal to the railroads and public utilities represents the second class. Under the system of control exercised by the Fuel Administration in 1918 and emulated by the Railroad Administration during the strike of 1919, the problem of geographic control of distribution was effected by the zones and distribution in regard to users was controlled by the priority lists.

Federal control of coal distribution in 1920, and of course there was such control, was exercised by the Interstate Commerce Commission through its power over transportation and coal cars under the Transportation Act of 1920. A study of the service orders of the commission will show how these two kinds of distribution were effected. To force coal to New England and to the Lakes for the Northwest, orders were issued requiring minimum deliveries or consignments each day by the operators to these sections and enforcing the mandate by embargoing shipments

from the mines until the respective minima had been fulfilled. In effect, the first cars to be loaded with coal at each mine in the fields affected were each day assigned either to the Lakes or to Tidewater for New England. The results sought were in each instance promptly attained and the plan worked after the first few weeks of tryout.

However, to get coal to a special class of users in all parts of the country made necessary some other method of control. Whereas the coal forced to New England was for any and all consumers in that section, there were parts of the country where no such broad action was considered necessary, but in which there were special users of coal who seemed to require particular attention. The most notable examples of this were the public utilities in New York and other cities on the Atlantic coast.

The problem here was to pick out from current production additional and special supplies for particular consumers without attempting to increase the total movement to that section of the country. This was effected by extending to public utilities the privileges of assigned cars, already a prerequisite of the railroads for obtaining their coal. Service orders were promulgated by the Interstate Commerce Commission making provision for this, the method in detail requiring that utilities in need of coal for current consumption, and unable otherwise to procure it, apply to the railroads and finally to the coal shippers for cars and coal assigned for this specific use. Because the lack of cars in which to load the coal was the only hindrance to getting all the fuel required, it is patent that having cars assigned provided sufficient incentive to shippers to give coal to those to whom such cars were given.

The privilege of assigned cars for public utilities and other public and semi-public consumers was withdrawn before the end of the season, mainly, it is understood, because of abuses in the practice. The plan was not so successful as that adopted for regional distribution and was opposed by the coal operators on general principles, but was favored by those who were the beneficiaries.

The West, Middle West and the South have demonstrated through the troublous past four years an ability, both as regards mine capacity and railroads, to take care of their normal markets. Any large dislocation in production and distribution, excepting of course those arising from major strikes of labor, comes in the coal fields of the middle and northern Appalachian regions—that is, from southern West Virginia north to and including Ohio and Pennsylvania. The coal fields in this area, from which comes nearly three-quarters of the total bituminous coal output of the country, not only are the source of supply for markets immediately adjacent, as in Pennsylvania and New York on the east and Ohio on the west, but these same fields must also meet the requirements of the North-

west, to which they ship via the Great Lakes; New England, to which coal is shipped all-rail from Pennsylvania fields and by rail and water from fields further south, and as well the requirements of ocean shipping for bunkers and foreign countries for cargo coal. In other words, the largest coal fields are large exporters of coal—to New England by rail, to the Northwest by way of the Lakes and to Atlantic Tidewater ports for a number of uses. In addition to these three major movements, there are insistent demands for coal from these fields for consumers in Michigan, Ohio, Indiana and, closer by, from Virginia.

The variety and magnitude of the demands on the coal fields of the northeastern United States make it plain why trouble is first encountered there and why so much effort was necessarily expended on this area in 1920. It was shown early in the summer that the deficiency of production in the fields from West Virginia north was at least 5,000,000 tons per month and that no measure of arbitrary distribution would meet the situation of impending shortage unless production in these fields was increased, and increased without materially decreasing that in other fields.

New England guessed wrong at the beginning of the year and had not definite and comprehensive steps been taken in her behalf by the Federal Government she would have had difficulty in getting the coal required without paying very highly for it. Consumers in New England have much to learn about the shifts that have taken place in the coal trade in the last four years, and until they approach their problem with more open minds and fuller recognition of their changed relations to the rest of the world in respect to bituminous coal, they will have trouble.

The Northwest, in particular the dock operators, is in a peculiar position in that a considerable portion of the coal used in that large section comprising the states of Minnesota, Wisconsin, North Dakota and parts of South Dakota and Iowa must be purchased and moved in the summer time, stored on the docks at the head of the Lakes and doled out during the cold weather. In the past, prior to the war, coal was cheapest in the summer time and the operators of the docks always were able to obtain their winter's supply, usually more than 20,000,000 tons, at very reasonable prices and could sell it to their customers at prices netting them a nice profit.

When coal reaches its highest price in the summer time, as in 1917 and 1920, however, the dock men are at a disadvantage. They pay high prices for what they get, and the following winter, when the rest of the country is enjoying lower prices, they must either pass on what they have in storage at high prices or accept a loss. As their customers have no other adequate source of supply, it can be assumed that they voluntarily pocket no loss.

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The theory on which the Lake trade has been built up was overturned in 1920. For instance, there is the matter of contracts. It does not appear to have been the custom for those who ship coal to lower Lake Erie ports to enter into even the usual form of coal contract with the dock buyers, because it usually has been so easy to obtain coal in the summer months for the Lake trade. The Lake outlet in the off season of summer enjoyed by Eastern operators has been observed with envious eyes by coal producers in the Middle West. Simple agreements to ship "what I may have available," at a price to be determined later, were this year magnified by some of the Northwest buyers and the Calder committee to read as hard-and-fast contracts and there has been much acrimonious debate because the shippers did not so construe them during the past season.

Tidewater Shipments

All records for shipments of soft coal to the Atlantic tidewater ports were broken in 1920. Compared with the previous maximum of nearly 43,000,000 net tons delivered over the North Atlantic piers in 1918, the figures for the first 11 months of 1920 exceed 49,500,000 net tons and the total for the year is estimated at more than 53,000,000 tons. In the five months July to November inclusive Tidewater dumping at these ports was at the rate of 63,000,000 net tons per year, and in October it was at the rate of more than 69,000,000 tons. For the first time export cargo exceeded every other item with a total in eleven months of more than 20,000,000 net tons. Exports off shore in 1917 were 5,500,000 net tons, or about one-fourth what they were in 1920. In 1918, because largely restricted, exports by water were but 3,700,000 tons, and in 1919 the record was the highest attained to that date—8,292,000 net tons. In the five months July to November inclusive, 1920, exports from the four North Atlantic ports were at the rate of 28,000,000 net tons per annum and in October at the rate of nearly 35,000,000 tons. Hampton Roads is the most important loading port for export cargo coal and in the period from the beginning of May to the end of the year 1920 the daily average was 50,000 net tons or at the rate of 1,250,000 tons per month or 15,000,000 tons a year.

Consumption

Rate of consumption of coal is the important factor in the situation over which the coal operators and the railroads have no control. The railroads are the largest individual consumers of coal, but their consumption is proportional to the freight that is offered. The rate at which coal is burned varies with the relative prosperity of industry and with the weather. Demand, as differing from consumption, is consumption plus

or minus the quantity of coal that is put into or taken from consumers storage and plus the difference between exports and imports.

Production in the period of a year is an approximate, rough measure of demand. To determine the quantity consumed in any period it is necessary to know also the extent of stocks at the beginning and end of the period. On the basis of such data as are available it is estimated that the consumption of bituminous coal in 1920 was 490,000,000 net tons, compared with 480,000,000 tons consumed in 1919, 525,000,000 tons in 1918, 502,000,000 tons in 1917 and 494,500,000 tons in 1916—that is, in respect to coal burned in the United States it appears that 1920 was about on a par with 1916. The difference in production in the two years, about 54,000,000 tons, is accounted for in the greater exports last year and the fact that in 1916 stocks were 11,000,000 tons less at the end of the year than at the beginning, whereas in 1920 about 21,000,000 tons were added to consumers' storage. In 1916 total exports both by land and water less imports were, in round numbers, 19,000,000 net tons, compared with more than 39,000,000 in 1920.

PRICES

New high records in spot prices for both bituminous coal and anthracite were set in 1920. Emerging from a severe winter following the six-weeks miners' strike, during which production was cut more than two-thirds, the stock piles of the country were the lowest of any recorded. No sooner had the prices fixed by the Government been lifted than consumers began to bid strenuously for coal, and under the impulse of this competitive bidding prices rose from an average of $2.50 to $9.50 in the middle of August. The weighted average spot price from April to the end of the year was $6.30. The weighted average contract price, considering not only those contracts dated in 1920 but those of earlier date, is estimated at $3.25. If it be assumed that one-fourth of the output was sold at the average spot price and that the remainder moved on the average contract figure, it is found that the average realization was $4 per net ton at the mines. The total value of the soft coal produced in 1920, based on this assumption, was $2,225,000,000, compared with $1,491,000,000 for the 579,000,000 tons produced in 1918. This represents an increase in value at the mines over the war year of $734,000,000, of which mine labor received in increased wages and bonuses not less than $234,000,000 and the producers $500,000,000.

In the accompanying diagram the current quotations on spot sales as reported from week to week in 1920 are reduced to one figure for all fields, properly weighted according to the relative tonnage from each, and in turn reduced to relatives by weeks compared with the average

government prices, taken as one hundred. Thus, starting at 100 on April 1, the index number of spot prices of bituminous coal as quoted for eighteen fields rose by the second week in August to 372, which means an increase of 272 per cent. At the end of the year spot prices had fallen until they were but 28 per cent. above the average government maximum in effect during the last of 1918, despite the fact that labor and other costs mounted in 1920 at least 40 per cent.

FIG. 2.—Relative spot price of bituminous coal in the United States during 1920.

Some indication of what coal cost the consumers in 1920 is found in statistics compiled by the Interstate Commerce Commission of quantity and cost of coal consumed by certain large railroads in locomotive service. However, as these data on costs include freight as well as the mine price of the coal, the figures are of value only as they give comparisons as between months and years. In the four months July to October, 1919, inclusive, for which the data are available, the range in average cost per ton for all roads was 5 cts. In the same months of 1920 the average cost of the coal used by the railroads reporting to the Interstate Commerce Commission ranged from $4.25 in July to $4.77 in October. Preliminary figures for November show a decrease to $4.70.

Cumulative average cost of 93,620,000 net tons consumed in the first ten months of 1920 was $4.05, compared with $3.24 per ton in the same period of 1919. It is significant of the change in the market in the two years that in 1919 average costs in the months of July to October were less

AVERAGE COST PER NET TON, INCLUDING FREIGHT, OF COAL CONSUMED BY LOCOMOTIVES IN ROAD SERVICE
(As reported by the Interstate Commerce Commission)

Region.	Month.							
	1919.				1920.			
	July.	Aug.	Sept.	Oct.	July.	Aug.	Sept.	Oct.
New England	$5.26	$5.01	$5.30	$5.59	$9.49	$9.57	$8.84	$7.84
Great Lakes	3.12	3.05	3.27	3.34	4.33	4.58	5.23	4.32
Ohio, Indiana—Allegheny	2.50	2.64	2.75	2.75	3.92	4.28	4.24	3.71
Pocohontas	2.45	2.65	2.59	2.62	4.06	4.48	4.38	3.62
Southern	3.06	3.02	2.91	3.14	3.97	4.42	4.15	3.78
Northwestern	3.75	3.72	3.43	3.70	4.38	4.79	4.43	4.22
Central Western	2.98	3.01	2.85	2.97	3.51	3.57	3.57	3.43
Southwestern	3.45	3.34	3.32	3.47	3.77	4.48	4.39	4.08
All regions	3.12	3.11	3.10	3.24	4.25	4.56	4.54	4.05

Region.	Cumulative from Beginning of the Year.							
	1919.				1920.			
	July.	Aug.	Sept.	Oct.	July.	Aug.	Sept.	Oct.
New England	$5.82	$5.76	$5.67	$4.99	$7.38	$7.75	$7.72	$9.21
Great Lakes	3.40	3.35	3.35	3.25	4.00	4.07	4.20	5.28
Ohio, Indiana—Allegheny	2.77	2.75	2.76	2.74	3.40	3.59	3.62	4.54
Pocohontas	2.60	2.60	2.60	2.81	3.26	3.42	3.52	4.46
Southern	3.24	3.20	3.15	3.00	3.51	3.58	3.69	4.52
Northwestern	3.86	3.83	3.49	3.63	4.07	4.18	4.04	4.86
Central Western	3.04	3.03	2.97	2.94	3.37	3.39	3.38	3.82
Southwestern	3.54	3.49	3.47	3.40	3.93	4.01	4.08	4.36
All regions	3.32	3.28	3.21	3.16	3.80	3.91	3.95	4.77

than the cumulative for the year, but in 1920, because of rising prices, average monthly costs after June were well above the average for the year to date. Despite the high spot prices in 1920, the railroads were able to obtain their coal at an average increase of but 75 cts. per net ton over 1919.

ANTHRACITE[1]

According to the records of shipments of anthracite as reported to the Anthracite Bureau of Information at Philadelphia, the total production for the calendar year 1920 showed an increase over that of 1919 of about 1 per cent., the total amounting to approximately 79,285,000 gross tons. In 1919, according to the U. S. Geological Survey, the total production was 78,501,931 gross tons. Excluding 1917 and 1918, in which production was abnormally stimulated in order to meet the demands created by the World War, and the output of which included exceptionally large amounts of "washery" coal, the average production of anthracite for the decade from 1910 to 1919 inclusive was 78,811,724 tons, an amount exceeded by the production in 1920 by about 475,000 tons. In both 1919

[1] E. W. Parker, Director, Anthracite Bureau of Information, *Coal Age*, Jan. 20, 1921.

and 1920 the anthracite industry was affected by influences which reduced the possible production by approximately 4,000,000 tons.

Following the release on Feb. 1, 1919, of government regulation of production and distribution of anthracite, and a winter of unusually mild temperature, the domestic demand fell off sharply, so that notwithstanding some 2,000,000 tons was mined and put in storage, the production in February fell below normal by about 1,500,000 tons; 2,000,000 tons more were lost in March and April showed a decrease of about 500,000 tons. The difficulty in meeting the demand, which was the pronounced feature of the trade during 1920, had its origin in the mistaken policy of consumers and dealers of cancelling orders and refusing to accept coal in the spring of 1919. The winter of 1919–20 was as abnormally severe as the preceding one had been mild, and the spring of 1920 opened with bins of dealers and cellars of householders practically bare of fuel.

The shortage created in 1919 would not, however, have been of serious moment except for the similar condition in 1920, brought about, first, by the outlaw switchmen's strike in the railroad yards in April, which so interfered with the movement of cars to and from the mines that the production of that month fell short about 1,250,000 tons, and second, by the "vacation" strike of miners in September, which was intended to voice their dissatisfaction with the award of the U. S. Anthracite Coal Commission and which resulted in curtailment of output by about 2,500,000 tons. An extra holiday in November (election day) reduced the tonnage for that month by about 250,000 tons.

Except for the incidents cited above the production of anthracite in each of the last two years would have amounted to about 83,000,000 gross tons. The shipments, by months, in both years as reported to the Anthracite Bureau of Information, are shown in the following table (shipments from the Bernice basin in Sullivan County are not included in this statement):

	1919.	1920.
January	6,066,689	5,868,835
February	3,951,898	5,046,483
March	4,016,290	6,077,821
April	5,326,363	4,814,211
May	5,817,756	6,155,878
June	5,737,472	6,319,957
July	6,189,740	6,389,100
August	6,241,809	6,207,653
September	5,786,282	3,592,954
October	6,671,891	6,240,901
November	6,066,501	5,765,347
December	6,251,736	†6,250,000
Total	68,124,427	68,729,140

† Estimated.

The calendar year opened auspiciously, the three months of January, February and March recording a normal production for that period and one considerably in excess of the corresponding period in 1919, when

output was below normal because of the slump in demand in February and March, following a mild winter and the release of government control over the production and distribution of anthracite. Trouble began with the first month of the coal year, April, when the effects of the "outlaw" switchmen's strike in the yards of the transportation companies was shown in a reduction of the shipments for that month to 4,812,153 tons. This strike was not of long duration, having expended its force about the 20th of the month, but it was enough to cause a loss in the production of anthracite of approximately 1,400,000 tons, as in the four succeeding months anthracite shipments averaged about 6,200,000 tons.

One disturbing factor of a local nature, but which reduced production by approximately 750,000 tons, was a strike in the mines of the Pennsylvania Coal Co. in the vicinity of Pittston in protest against the contracting system employed by that company in operating certain portions of its properties. This strike, which began early in July, when the Anthracite Wage Commission was sitting at Scranton, affected some 10,000 men and was continued for nearly three months. It was finally settled through the action of the contractors in giving up their contracts. The contracting system had been the subject of some controversy in the adjustment of wage agreements for a number of years, but had never before assumed such serious proportions. It is now in the discard.

As a result of the outlaw switchmen's strike in April and the miners' "vacations" in September, the production of anthracite for the eight months of the coal year beginning April 1 and ending Nov. 30 showed a decrease of 1,550,000 gross tons, as compared with the preceding year. The decrease in production of domestic sizes was more than twice as much as the decrease in total tonnage, for the quantity of coal recovered by washeries from the culm banks this year exceeded that of 1919 and made up in part, by larger output of steam sizes, the smaller production of domestic coal. The output of fresh-mined coal, which furnishes the domestic sizes, is about 3,700,000 tons below what it was last year, a situation for which the "vacation" strikes and numerous holidays are directly responsible.

The situation in New England was aggravated by the embargoes placed against anthracite shipments by the railroads serving that territory. From April 1 to Aug. 31, a period of 150 days, there were only 30 days that anthracite could be shipped without special permit into the territory served by the New York, New Haven & Hartford R.R. During the same period embargoes were in effect on the Boston & Maine and on the Boston & Albany for a total of 78 days each. Movement by water to Sound and Atlantic Coast ports was prevented for about two months by the strike of the towboat men in New York Harbor.

One of the most unfortunate developments of the year arising from the disturbance of the regular methods of distribution, due to the causes already referred to, was the creation during the last half of the year of a feeling of apprehension in the minds of dealers and consumers who had not been able to secure their full supplies that the arrival of cold weather would find them without fuel. In no inconsiderable part of the anthracite-consuming territory this feeling of apprehension partook somewhat of the nature of panic, which resulted in a scramble for coal unprecedented in the history of the industry.

Consumers and dealers were bidding against each other for any free coal that was to be had—that is, coal that was at the disposal of operators and middlemen and which was not committed to a regular trade—which naturally had the effect of skyrocketing prices on such tonnage as was available. The proportion of the anthracite production affected by this situation was less than 1 per cent. of the total output, but the publicity given to it and the advantage taken of it by some retail dealers to base the prices of all of their coal on the high-cost portion of it created an impression that producers generally were taking advantage of the situation to mulct the public, whereas as a matter of fact by far the larger part of the production has been sold at prices that were not only reasonable but were actually below what would have been justified by the increased cost of production and the earning of profit on the capital invested.

Government participation in the problems that confronted the anthracite industry in 1920 was not confined to the Department of Justice, for the Senate Committee on Reconstruction and Production, of which William M. Calder was chairman, extended its activities to include investigations of the coal business, notwithstanding the fact that a subcommittee of the Committee on Interstate and Foreign Commerce, of which Senator Frelinghuysen was chairman, was considering the same subject.

STOCKS[1]

Stocks of coal are significant because they are the consumer's reserve against a possible interruption in supply. Such interruptions have occurred in the past through mine strikes, traffic congestion on the railroads, or severe weather interfering with the delivery of loaded coal. When stocks are large, consumers can delay purchasing until offered favorable terms. Small stocks, on the contrary, drive many consumers to enter the spot market and conduce to higher prices. The condition of stocks, therefore, has an important effect on the coal market and is a matter of consequence to all who buy and sell coal in quantity.

In considering stocks a sharp distinction must be made between anthracite and bituminous coal. Although the two fuels are in competition, the business of mining and distributing them are so distinct as to be practically separate industries.

[1] Extracts from a preliminary report prepared by F. G. Tryon and issued by the U. S. Geological Survey, Apr. 30, 1921; based on returns to a questionnaire sent to producers, distributors, and consumers.

A final estimate of the total stocks on hand can not be made until more complete returns are received from consumers. It is, however, possible to state that the stocks on hand as of Jan. 1, 1921, were somewhere between 42 and 48 million tons—say 45 million, and that on Apr. 1 they had fallen to somewhere between 34 and 39 million —say 37 million. In the following table are given the stocks at various times in the past.

ESTIMATED TOTAL COMMERCIAL STOCKS OF BITUMINOUS COAL IN THE UNITED STATES (a)

	Net Tons.		Net Tons.
Oct. 1, 1916	27,000,000	Jan. 1, 1919	57,900,000
Oct. 1, 1917	28,100,000	Apr. 1, 1919	40,400,000
July 15, 1918	39,700,000	Mar. 1, 1920	24,000,000
Oct. 1, 1918	59,000,000	June 1, 1920	20,000,000
Day of the Armistice	63,000,000	Jan. 1, 1921	about 45,000,000

(a) Coal in transit not included.

During the war actual counts of the stocks of all commercial consumers were made by the Fuel Administration, and the stocks of an entire class of plants are found to vary with those of a representative sample drawn at random from the class. To compare stocks in different localities or in different types of plants, a common denominator is necessary; such a common term is found by expressing the stocks in the form of weeks' supply at the current rate of consumption. Thus if the 283 railroads from whom schedules had been received at the time this report was prepared showed an average supply of 3 weeks and 5 days, the average might be assumed to apply to all roads.

The course of stocks at the 3779 identical plants reporting to date epitomized the present condition of consumers' stocks. At the beginning of 1921 consumers' reserves were comfortably large. In the 3 months which followed they were heavily drawn upon. The quantity remaining on Apr. 1 was less than the abundant stock of early 1919, but much greater than the stock in the period of scarcity of 1920.

WEEKS' SUPPLY OF BITUMINOUS COAL HELD BY THE RAILROADS

(Figures represent supply in weeks and days at current rate of consumption at time of stock-taking)

July 1, 1918	3–4	Mar. 1, 1920	1–4*
Oct. 1, 1918	4–1	June 1, 1920	1–3*
Nov. 11, 1918	4–3	Jan. 1, 1921	3–5
Jan. 1, 1919	4–4	Apr. 1, 1921	3–5

* Probably low.

Bituminous Coal in Transit

Lake Docks.—The coal transit forms a sort of mobile reserve as opposed to the stationary reserve in the bins of consumers. This mobile reserve includes not only the coal in cars, but also the coal on the commercial docks at the head of the Lakes. The tonnage on the docks is normally greatest in the fall at close of navigation, and least in the spring when navigation opens.

According to the Northwestern Dock Operators' Association, the carry-over at the beginning of the past four seasons has been:

Bituminous Coal on Hand at Opening of Navigation as Reported by 24 Distributing Dock Companies on Lake Superior and Lake Michigan

	Net Tons.
Apr. 1, 1917	572,687
Apr. 1, 1918	1,031,978
Apr. 1, 1919	3,374,503
Apr. 1, 1920	860,521

Complete returns concerning the carry-over on Apr. 1, 1921, are not yet available, but the total is thought to be at least 2,250,000 tons. The following statement shows

the bituminous coal on hand at the opening of navigation, held by companies now reporting to the Northwestern Coal Dock Operators' Association. Though incomplete, the figures cover an identical group of companies operating at Duluth, Superior, Ashland and Washburn.

1917	387,968
1918	987,246
1919	2,439,749
1920	514,902
1921	1,643,034

Though smaller than in 1919, the 1921 carry-over was thus much larger than in either of the war years, and three times as great as last year.

Coal at Tidewater.—Coal in cars sometimes accumulates in volume at tide-water piers. How the tonnage has fluctuated in the past two years is suggested by the accompanying statement of the quantity on hand at two of the three piers at Hampton Roads, the country's leading port of export. As in other instances in this report, the figures are samples only.

	Net Tons.
Jan. 1, 1919	138,000
Apr. 1, 1919	198,000
Mar. 1, 1920	138,000
June 1, 1920	234,000
Jan. 1, 1921	199,000
Apr. 1, 1921	296,000

The tonnage on hand Apr. 1, 1921, was nearly 100,000 tons greater than on Jan. 1.

At New England Gateways.—Coal seldom accumulates at the New England rail gateways over the Hudson in volume sufficient to constitute an important item in the mobile reserve. On Apr. 2, for example, the number of cars of soft coal waiting to be forwarded to New England was only 286, equivalent to about 14,000 tons.

Anthracite Stocks

Producers' Stocks of Anthracite.—The steady operation of the anthracite mines at a time when the bituminous mines have been working but 2 or 3 days a week has been made possible to some extent by the accommodation of part of the output in the storage yards of the producers. Whereas storage of bituminous coal by the producer is so rare in the United States as to be practically non-existent, the larger anthracite companies have constructed storage yards to receive their excess production in times of low demand. According to the Federal Trade Commission, the stocks of anthracite in the hands of the principal producers were as follows in the 5 years before the war:

	Gross Tons.
Apr. 1, 1913	3,891,711
Apr. 1, 1914	5,223,844
Apr. 1, 1915	7,406,502
Apr. 1, 1916	4,585,906
Apr. 1, 1917	894,347

What the total in storage amounts to now is not known, but from the following table based on reports from 7 large companies comprising the bulk of the tonnage, it will be seen that present stocks are smaller than those of 1913–1916 though greater than those of early 1917.

ANTHRACITE HELD IN STORAGE BY SEVEN OF THE LARGEST PRODUCERS (a)
(Gross tons.)

Date.	Domestic Sizes Including Pea.	Steam Sizes.	Total.
Jan. 1, 1919	227,197	638,388	866,185
Apr. 1, 1919	907,002	850,879	1,757,881
Mar. 1, 1920	259,617	909,970	1,169,587
June 1, 1920	385,095	576,974	962,069
Jan. 1, 1921	124,354	353,571	477,925
Apr. 1, 1921	371,088	987,888	1,358,976

(a) Includes coal on the Lake Docks.

Anthracite in Transit.—The quantity of anthracite in cars at tidewater on Apr. 1, was about the same as on the corresponding date of recent years.

Anthracite lying on the docks at the head of Lake Superior is properly to be regarded as coal in transit. The quantity on hand Apr. 1 was larger than in 1917 and 1918, but smaller than in 1919 and 1920. The following data covering most but not all of the dock companies are published by permission of the Northwest Coal Dock Operators Association.

	Net Tons.
Apr. 1, 1917	8,294
Apr. 1, 1918	3,955
Apr. 1, 1919	134,911
Apr. 1, 1920	103,867
Apr. 1, 1921	83,893

Retailers' Stocks of Anthracite.—Retail coal merchants appear to have as much or more anthracite on hand as at any time in the past two years. Reports received from 813 representative dealers in anthracite in the 24 states where Pennsylvania anthracite is sold in significant amounts showed the following quantities on hand.

	Net Tons.
Jan. 1, 1919	980,000
Apr. 1, 1919	865,000
Mar. 1, 1920	843,000
June 1, 1920	623,000
Jan. 1, 1921	874,000
Apr. 1, 1921	1,323,000

If the situation of these dealers is typical of the trade in general, there was an increase of nearly 50 per cent. in retailers' yards from January 1 to April 1. The increase was general throughout New England and the Middle Atlantic States, and as far south as Virginia and west as Indiana and Michigan.

In striking contrast to the East, stocks decreased in Illinois, Missouri, Iowa, Nebraska and the territory supplied from the Lake Docks. Even in these States, however, the stock in retailers' yards on Apr. 1, averaged from 2 to 6 weeks' supply at the rate of delivery prevailing from January to March. For the entire group of 813 merchants the average supply was sufficient for 5 weeks, 1 day.

In comparison with either 1919 or 1920 retailers' stocks at present show a very general increase.

ALASKA

One of the most important events of 1920 in Alaska was the beginning of systematic underground exploration of the Matanuska coal field under

the auspices of the Navy Department. Mining was continued in this field also by the Alaskan Engineering Commission on about the same scale as in previous years, to obtain fuel for the railroad and the nearby towns. Much underground work was done by the Bering River Coal Co. in the western part of the Bering River field, but no coal was produced except for use at the mine. The Alaska Coal & Petroleum Co. also continued underground explorations in the eastern part of the field.

The completion of the railroad between Fairbanks and Healy Creek (except for the Tanana River bridge) early in 1920 made the Nenana coal accessible, but the temporary bridge at Nenana River was washed out by a flood, and the coal was carried across the river by aerial tram. During 1920 coal was mined in the Nenana field at the Burns and Calderhead mines, operated under temporary permits. A lease was granted to the Healy River Coal Mining Co. in the same field. Lignitic coal also was mined on a small scale in the Cook Inlet region and in other parts of Alaska. A coal land lease was granted in the Cook Inlet field. The coal production in 1920 was about 68,000 tons; that in 1919 was 60,674 tons. The value of the 1920 production is placed at $380,000; that of 1919 at $343,547.

Imports and Exports

The following is a comparative statement of imports and exports of the United States for the past 4 years, in long tons:

	1917.	1918.	1919.	1920.
Imports:				
Anthracite, total	11,188	33,279	73,945	28,346
Bituminous, total	1,293,262	1,300,958	903,170	1,111,598
United Kingdom	9,300	33,390	1,884	7,403
Canada	1,250,709	1,250,933	825,123	1,003,485
Japan	17,513	14,214	6,617	25,364
Australia	12,148	1,369	67,503	68,234
Other countries	2,592	1,052	2,043	7,112
Coke	22,207	26,936	14,720	36,735
Exports:				
Anthracite, total	5,363,666	4,435,543	4,443,391	4,824,776
Bituminous, total	21,285,320	19,956,009	17,958,514	34,390,254
Italy	560,628	9,994	1,632,995	2,387,734
Canada	16,177,571	16,191,364	10,669,890	14,482,929
Panama	618,962	504,126	72,097	155,042
Mexico	184,345	162,631	101,679	203,212
Cuba	1,410,594	1,440,457	971,399	1,332,632
West Indies	402,812	254,501	287,744	371,560
Argentina	317,562	178,899	483,389	1,718,493
Brazil	685,142	559,099	634,109	965,019
Chile	.....	300,062	93,618	494,121
Uruguay	60,188	228,959	194,997	267,807
Other countries	867,515	125,917	2,816,597	12,011,705
Total coal	26,648,986	24,391,552	22,401,905	39,215,030
Coke	1,258,321	1,506,986	640,139	821,252
Bunker coal	6,883,176	5,532,175	7,342,734	9,362,178

Coal Research by the U. S. Bureau of Mines[1]

Perhaps the most outstanding feature in the coal industry during the past year has been the universal recognition of the absolute dependence of the whole country on coal as the keystone of present industrial and home life. So long as coal could be had cheaply whenever desired, the details of its mining, preparation, transportation and selling were of interest only to the trade. Even during the war it was felt that the derangement of pre-war conditions of general oversupply was only temporary.

However, the continued undersupply at major points of consumption and the unheard-of prices, affecting directly almost every individual in the country, have combined to make coal the most discussed of necessary commodities. This has been strikingly evidenced to the Bureau of Mines in the number and character of letters received asking for information. While the number asking for information on the technical points of mining has not decreased, the number asking for information on the economic aspects of the coal industry has markedly increased.

The separate components which when assembled make up the whole coal situation are mine operation, coal preparation, transportation, marketing and utilization. Because of its broad organic law covering these points and its non-partisan character the Bureau is often able to review these separate and necessary components, to correlate them and to broadly gage their trend. Thus to the consumer the questions of importance concern impurities, kinds of coal adapted for particular uses, and small percentage savings by reason of better equipment. These questions were largely of academic interest when coal cost less than a dollar a ton at the mouth of the mine. Now, however, the continued higher price-level is bringing out many devices and schemes to save fuel, is causing the larger plants to employ technically-trained combustion engineers and is stimulating real interest in devices and ways to save fuel that are already on the market.

In the aggregate and if continued over a period of time this condition will bring reaction in the coal-producing industry, not because it will be possible generally to substitute other fuel for coal, but because it will tend to put into effect the 15 to 40-per cent. savings in fuel that are possible at most boiler-plants, including house-heating devices, by the exercise of proper care and the use of improved equipment. For this reason, over a term of years high price will surely lessen relative demand.

The high price and scarcity of coal have also been responsible for the appearance of a great crop of substitute fuels and processes, many of them with considerable technical merit. The coal industry, however, should not overlook that the real test of a ubstitute or artificially prepared fuel is not always its technical mserit, but rather whether the cost of producing the new fuel is low enough per ton to admit of its commercial competition with natural coal under present and prospective prices. In any case the margin between profit and loss is not great and the production of an artificially prepared fuel must be considered as a competitive business rather than as a development of an invention having before it a clear field.

There are immense high-grade coal areas in the United States still untouched, and until their possibilities have been fully developed, coal in its natural state must necessarily continue to be the chief fuel of the country. However, the use of raw bituminous coal in our great cities is rapidly approaching the point where it becomes a nuisance and a possible menace. Here, for reasons other than cheapness, a smokeless prepared fuel of reasonable price awaits a ready market.

The public has been educated as never before to the advantages of buying and

[1] E. A. Holbrook, Assistant Director, U. S. Bureau of Mines, *Coal Age*, Jan. 20, 1921.

stocking coal in the seasons of small demand and oversupply. At times this is a money-saving operation; in every case it is an insurance against shut-down and uncertainty during the periods of greatest demand. In spite of local opinion to the contrary, practically every kind of coal can be stored, providing those in charge have the full available information and knowledge of the storage problem and see that their orders are strictly carried out.

In the actual operations of mining coal, each year sees real progress. The safety-first movement, which ten years ago was largely humanitarian in character, has become a commercial necessity. No work is projected or carried out, no methods are put into use, no machinery installed, without considering the real test: Is it safe? Practical cost and technical excellence must take second place to safety qualities.

There are, however, such continual changes in the methods and machinery of coal mining that continual investigation of the new hazards and formulation of rules safeguarding them are necessary. For example, electricity, which seemed ten years ago to have reached in mines a high state of use and development, is today spreading in use and in usefulness in mines as never before. The simple rules and regulations formulated to safeguard its use ten years ago are today inadequate and possibly hazardous in the great modern fully-electrified operation. Continual study of new conditions must be made and recommendations offered. The problems are complex and do not admit of a sudden snap judgment or opinion on the part of any of the interested parties. Rather, long-continued observation and compilation of data, as the use of electricity underground becomes more complex, are the only safe guides in controlling its hazards.

Never before have such earnest efforts been made to perfect mechanical underground loading devices for coal mines. There is no doubt that the continual upward trend in the cost of mining coal will greatly stimulate the development and introduction of mechanical mining and loading devices. As in other industries where machinery has replaced hand labor, this will not mean a decrease in the number of men employed, but rather a change of their duties, and probably will bring about in turn a new cycle of lessened costs and a large increase in the amount of coal mined.

With all these and other movements in the industry the Bureau of Mines endeavors to keep in touch, to co-operate, and to assist. It possesses and desires no police powers; rather it is the one agency in touch with coal mining in every state, and through investigation and research and by reason of its contact with the many different mines and conditions it is able to point out what are believed to be the best practices and to give direct co-operation when it is asked for.

Of particular interest is the fact that the Bureau during the past year has noted in the coal industry a great and unprecedented demand for and absorption of technically trained men. While this is partly accounted for by the general prosperity of the industry, it is doubtless of deeper significance. The increasing size and depths of the mines, the greater use of machinery and the increased price of available coal acreage all necessitate the employment of men who have special training and knowledge.

The developments in coal preparation should not be overlooked. With a return to normal the public, now becoming educated in regard to coal, is going to demand clean, well-prepared coal. The increasing freight-rates further act as a deterrent to shipping low-grade or high-ash coals. Knowledge of the impurity sulphur, its effect in coal and coke and the possibilities of its removal have attracted attention as never before. Coal washing, if the price of coal keeps at or near its present level, will see a development in processes and use during the next ten years comparable only with the progress made in its sister art of ore dressing during the past ten years.

Coal Mine Fatalities[1]

Reports received by the U. S. Bureau of Mines from state mine inspectors indicate a reduction of about 2.2 per cent. in the number of coal-mine fatalities during 1920 as compared with the previous year.

The figures show that the number of lives lost was 2260, a decrease of 57 from the record of 1919. This reduction in the number of fatalities is particularly gratifying because it was accompanied by an increase of about 18 per cent. in the output of coal. The fatality rate in 1920 was 3.50 per million tons mined and 4.24 per million tons in 1919.

Complete information is not available to show the number of men employed in coal mining either in 1919 or 1920. However, if we use the record for 1918 as a basis, we may estimate the total number of days of labor performed by all employees in 1919 and 1920, which represents the period of time during which the employees were exposed to the hazards of mining. Such an estimate enables one to judge, with a reasonable degree of accuracy, the fatality rates for the past two years on a uniform working-time basis.

For 1918 the record shows that 762,426 employees performed 196,491,984 days of labor and produced 678,211,904 tons of coal, a daily average of 3.45 tons per man. Assuming that the individual daily output has not fallen below this record, the production figures for the last two years show that the total working time during the calendar years 1919 and 1920 was, roughly speaking, equivalent to 158,000,000 man-days and 187,000,000 man-days, respectively.

Based upon the number of full-time (300-day) workers, therefore, the fatality rate per thousand employees was 3.94 in 1918, and is estimated at 4.39 for 1919 and 3.63 for 1920.

Considered by causes the most notable decrease in fatalities was in the number due to explosives. This class of accidents showed a reduction of about 38 per cent. There also was a gratifying decrease in the number killed in explosions of gas and coal dust. Practically no change occurred in fatalities due to falls of roof and coal, or to the use of underground haulage. Surface accidents caused by mine cars and locomotives and railway cars decreased about 19 per cent.

FATALITIES AT COAL MINES IN THE UNITED STATES

	1917.	1918.	1919.	1920.
Underground:				
Falls of roof or face	1,230	1,294	1,100	1,127
Haulage	488	506	381	405
Gas and dust explosions	360	129	191	164
Explosives	110	135	206	127
Electricity	79	88	69	76
Miscellaneous	108	129	130	112
Shaft:				
Miscellaneous	60	52	53	56
Surface:				
Haulage	110	118	93	78
Machinery	46	40	22	24
All others	105	89	92	91
Total	2,696	2,580	2,317	2,260

[1] W. W. Adams, Statistician, U. S. Bureau of Mines, *Coal Age*, Jan. 20, 1921.

COAL MINE FATALITIES BY MONTHS, 1917–20

	1917.	1918.	1919.	1920.
January	227	215	186	196
February	168	222	157	146
March	230	196	172	168
April	309	215	189	151
May	181	211	175	153
June	232	230	293	204
July	247	276	220	186
August	269	249	226	184
September	181	230	181	179
October	197	214	234	179
November	230	157	88	172
December	225	165	196	287
Total	2,696	2,580	2,317	2,260

The principal mine disasters reported in 1920 were: April 14, Dawson mines Nos. 1 and 6, Dawson, N. M., dust explosion, 5 killed; May 3, Submarine mine, Clinton, Ind., gas explosion, 5 killed; June 2, Ontario mine, Cokeburg, Pa., gas explosion, 6 killed; July 19, Union mine, Renton, Pa., gas explosion, 9 killed; July 26, No. 6 mine, Sublet, Wyo., explosion of powder magazine, 8 killed; August 21, No. 19 mine, Degnan, Okla., gas explosion, 10 killed; November 16, Arnold mine, Earlington, Ky., mine fire, 6 killed; November 23, Parrish mine, Parrish, Ala., gas explosion, 12 killed. These eight disasters resulted in the death of 61 men, as compared with nine similar disasters in 1919 which caused the death of 201 men.

Fuel Briquetting in 1920

A new record in the production of fuel briquets was established in 1920, according to reports made to the United States Geological Survey by the operators of briquetting plants. The total output was 567,192 short tons, nearly double that of 1919 and 19 per cent. above that of the war year, 1918, hitherto the maximum. The value at the works was about $4,250,000, an average of $7.50 per ton.

FUEL BRIQUETS PRODUCED IN THE UNITED STATES

Year.	Quantity (Net Tons).	Value.
1914	250,635	$1,154,678
1915	221,537	1,035,716
1916	295,155	1,445,662
1917	406,856	2,233,888
1918	477,235	3,212,793
1919	295,734	2,301,054
1920	567,192	4,250,000

In comparison with 1919, production increased in all districts, but the increase over 1918 came chiefly from plants along the Atlantic Seaboard operating on anthracite fines. In that region 3 new plants were put in operation, one at Newark, New Jersey, one at Lykens, Pennsylvania, and one at New York, all using anthracite as a raw fuel.

RAW FUELS USED IN MAKING BRIQUETS
(In net tons)

	1918.	1919.	1920.
Anthracite culm and fine sizes	209,690	104,027	330,136
Semi-anthracite Semi-bituminous Bituminous slack	180,714	111,955	152,247
Lignite and sub-bituminous coal Oil-gas residue	76,602	80,383	89,656
Total	467,006	296,365	572,039

Of the 15 plants in operation in 1920, 8 used anthracite as a raw material, 1 Arkansas semi-anthracite, 1 a mixture of anthracite and bituminous slack, 1 semi-bituminous slack, 1 a mixture of bituminous slack and sub-bituminous coal, 1 brown lignite, and 2 carbon residue from the manufacture of oil gas.

Coke in the United States

According to preliminary returns made to the Geological Survey by operators of by-product coke plants, the total production of by-product coke during the calendar year 1920 was 30,908,000 net tons. This was an increase of 5,764,000 tons over 1919, and exceeded by 4,910,000 tons the production of 1918, hitherto the record year. More than 850 new ovens were put in operation, and 580 more were reported under construction at the close of the year.

As the output of beehive coke is estimated at 20,980,000 tons, the total production of all coke (excluding gas-house coke) was 51,888,000 tons, of which 40.4 per cent. was made in beehive ovens and 59.6 per cent. in by-product ovens.

COKE PRODUCTION IN THE UNITED STATES

	Beehive, Net Tons.	By-product, Net Tons.	Total, Net Tons.
1893	9,464,730	12,850	9,477,580
1900	19,457,621	1,075,727	20,533,348
1910	34,570,076	7,138,734	41,708,810
1915	27,508,255	14,072,895	41,581,150
1916	35,464,224	19,069,361	54,533,585
1917	33,167,548	22,439,280	55,606,828
1918	30,480,605	25,997,580	56,478,185
1919	19,650,000	25,143,542	44,793,542
1920 (preliminary figures)	20,980,000	30,908,000	51,888,000

The following table gives the production, by states, during the last three years. The output in 1920 exceeded that of 1919 in all but two States, Washington and New Jersey. In comparison with the war year, 1918, increases were reported in 8 out of the 15 states for which statistics may be published without divulging individual returns. The most notable increase in comparison with 1918, both relatively and absolutely, was reported from Pennsylvania. In that State 7,710,000 tons was produced in 1920, an increase of 3,123,000 tons, or 68 per cent., over 1918.

PRODUCTION OF BY-PRODUCT COKE BY STATES (c)
(In net tons, excluding screenings and breeze)

State.	1918.	1919.	1920.
Alabama	2,634,451	2,230,933	3,075,000
Colorado	230,663	412,863	511,000
Illinois	2,285,610	1,703,903	2,086,000
Indiana	3,898,215	3,702,180	4,567,000
Kentucky	517,749	408,278	466,000
Maryland	474,368	356,237	685,000
Massachusetts	556,397	393,331	531,000
Michigan	(a)	(a)	1,433,000
Minnesota	784,065	586,094	664,000
New Jersey	682,148	788,465	722,000
New York	1,069,587	751,067	1,041,000
Ohio	5,226,334	5,374,027	5,697,000
Pennsylvania	4,586,981	5,872,762	7,710,000
Tennessee	124,469	104,749	138,000
Washington	30,129	26,547	23,000
West Virginia	603,393	392,812	414,000
Michigan[b], Missouri, Rhode Island and Wisconsin	2,293,021	2,039,294	1,145,000
Total	25,997,580	25,143,542	30,908,000

(a) Included in combined States. (b) 1918 and 1919 only.
(c) Prepared by F. G. Tryon, U. S. Geol. Surv.

By-product Coke Plants in the United States

The following list of manufacturers of by-product coke in the United States May 1, 1921, has been compiled by the United States Geological Survey:

Operator.	Name or Location of Works.	Number and Kind of Ovens.
Alabama:		
Alabama By-Products Corp	Birmingham	50 Koppers
Gulf States Steel Co	Alabama City	37 Koppers
Semet-Solvay Co.		
Also in Ill., Ky., Mich., N.Y., Ohio, Pa., W. Va.		
(Tenn. C. I. & R.R. Co.)	Ensley	240 Semet-Solvay
(Central Iron & Coal Co.)	Tuscaloosa	60 Semet-Solvay
Sloss-Sheffield Steel & Iron Co	Birmingham	120 Semet-Solvay
Tennessee Coal, Iron & R.R. Co	Fairfield	434 Koppers
Woodward Iron Co	Woodward	80 Koppers 60 Wilputte 90 Koppers being rebuilt
Colorado:		
Colorado Fuel & Iron Co	Minnequa	120 Koppers
Illinois:		
Chicago By-Product Coke Co	Chicago	100 Koppers building
Coal Products Mfg. Co	Joliet	35 Koppers 18 Wilputte
Illinois Steel Co. (Also in Ind.)	Joliet	280 Koppers
International Harvester Co	South Chicago	88 Wilputte
North Shore Gas Co	Waukegan	13 Semet-Solvay
St. Louis Coke & Chemical Co	Granite City	80 Roberts 240 Roberts building
Semet-Solvay Co. (Also in Ala., etc.) (By-Products Coke Corp.)	South Chicago	280 Semet-Solvay
Indiana:		
Central Indiana Gas Co	Muncie	22 Klonne
Citizens Gas Co	Langsdale	41 Semet-Solvay
	Prospect	100 United-Otto 40 Wilputte
Illinois Steel Co. (Also in Ill.)	Gary	700 Koppers
Indiana Coke & Gas Co	Terre Haute	30 Gas Machinery 30 Koppers
Inland Steel Co	Indiana Harbor	130 Koppers
Linton Gas Co	Linton	3 Gas Machinery
Steel & Tube Co. of America (Also in Wis.)	Indiana Harbor	120 Semet-Solvay
Kentucky:		
Semet-Solvay Co. (Also in Ala., etc.) (Kentucky Solvay Coke Co.)	Ashland	108 Semet-Solvay
Maryland:		
Bethlehem Steel Co. (Also in Pa.)	Sparrows Point	300 Koppers
Massachusetts:		
New England Fuel & Trans. Co	Everett	400 United-Otto

Michigan:		
Ford Motor Co.	Dearborn	120 Semet-Solvay
Michigan Alkali Co.	Wyandotte	54 United-Otto
Semet-Solvay Co. (Also in Ala., etc.)	Detroit	215 Semet-Solvay
Minnesota:		
Minnesota By-Product Coke Co.	St. Paul	65 Koppers
Minnesota Steel Co.	Duluth	90 Koppers
Zenith Furnace Co.	West Duluth	65 United-Otto
Missouri:		
Laclede Gas Light Co.	St. Louis	56 Koppers
New Jersey:		8 Piette building
Camden Coke Co.	Camden	150 United-Otto
Seaboard By-Product Co.	Kearny	165 Koppers
New York:		
Donner-Union Coke Crop	Buffalo	150 Koppers
Empire Coke Co.	Geneva	46 Semet-Solvay
Lackawanna Steel Co.	Lackawanna	94 United-Otto 282 Rothberg 60 Semet-Solvay
Semet-Solvay Co. (Also in Ala., etc.)	Solvay	40 Semet-Solvay
(Wickwire Steel Co.)	Buffalo	60 Semet-Solvay
Ohio:		
American Steel & Wire Co.	Cleveland	180 Koppers
Brier Hill Steel Co.	Youngstown	84 Koppers
Hamilton-Otto Coke Co.	Kokotto	100 United-Otto
McKinney Steel Co.	River Furnaces	204 Koppers
National Tube Co.	Lorain	208 Koppers
Penn Iron & Coal Co.	Canal Dover	24 Roberts
Republic Iron & Steel Co.	Youngstown	143 Koppers
Semet-Solvay Co. (Also in Ala., etc.)		
(Otis Steel Co.)	Cleveland	100 Semet-Solvay
(Ironton Solvay Coke Co.)	Ironton	60 Semet-Solvay
(Portsmouth-Solvay Coke Co.)	Portsmouth	108 Semet-Solvay
Toledo Furnace Co.	Toledo	94 Koppers
United Furnace Co.	Canton	47 Koppers
The Youngstown Sheet & Tube Co.	Youngstown	306 Koppers
Pennsylvania:		
Allegheny By-Product Coke Co.	Glassport	120 United-Otto
Bethlehem Steel Co. (Also in Md.)	Bethlehem	424 Koppers
	Lebanon	90 Semet-Solvay
	Steelton	120 Semet-Solvay 60 Koppers
Cambria Steel Co.	Franklin	210 United-Otto 92 Koppers 190 Cambria-Belgian
	Rosedale	60 Camb.-Belg. bldg. 60 Cambria-Belgian 88 Semet-Solvay bldg.
Carnegie Steel Co.	Clairton	768 Koppers
	Farrell	212 United-Otto
Jones & Laughlin Steel Co.	Pittsburgh	300 Koppers
Philadelphia Suburban Gas & Electric Co.	Chester	40 Semet-Solvay
Pittsburgh Crucible Steel Co.	Midland	100 Koppers
Rainey-Wood Coke Co.	Swedeland	110 Koppers
Semet-Solvay Co. (Also in Ala., etc.)		
(American Manganese Mfg. Co.)	Dunbar	110 Semet-Solvay
Rhode Island:		
Providence Gas Co.	Sassafras Point	40 Koppers
Tennessee:		
Chattanooga Coke & Gas Co.	Alton Park	24 Semet-Solvay
Washington:		
Seattle Lighting Co.	Seattle	20 Klonne
West Virginia:		
Domestic Coke Corp.	Fairmont	60 Koppers
La Belle Iron Works	Follansbee	94 Koppers
Semet-Solvay Co. (Also in Ala., etc.)		
(National Tube Co.)	Benwood	120 Semet-Solvay
Wisconsin:		
Milwaukee Coke & Gas Co.	Milwaukee	120 Semet-Solvay
Steel & Tube Co. of America	Mayville	108 United-Otto

Coal By-Products In 1919 and 1920

In the transition from the war status of 1918 to the period of readjustment in 1919, notable changes took place in the by-products industry. A decline in the production of toluol from 8,861,948 gal. in 1918 to 1,160,136 gal. in 1919 and 3,027,000 gal. in 1920, reflected the collapse

of prices on the cessation of munitions manufacture after the armistice. The output of benzol, however, greatly increased, rising from 44,804,900 gal. in 1918 to 61,067,502 gal. in 1919 and 80,950,000 gal. in 1920. Much of the benzol produced in 1919 and 1920 was in the form of motor benzol. As these figures do not include recoveries at refining establishments independent of coke-ovens, nor the entire output of coal, oil- and water-gas plants, they are far from representing the total production of benzol and toluol. Naphthalene production decreased sharply. The output of ammonia in 1919 was equivalent to a total recovery of 746,000,000 lb. of sulphate of ammonia, and in 1920 to 935,000,000 lb. Of the 476,000,000 M of gas produced in 1920, 237,000,000 was used in heating coke-ovens and 12,000,000 M was wasted.

The table summarizes reports received by the Geological Survey from operators of by-product coke-ovens covering the year 1920. The statistics are subject to revision on receipt of final reports from two companies for which at present complete information is not available. The total value of the by-products sold including gas used about the works for other purposes than heating by-product ovens was $93,626,000.

To recover these by-products required the carbonization of 44,224,000 net tons of coal. The quantity of merchantable coke produced was 30,781,000 tons, indicating a yield of coke from coal of 69.6 per cent. In addition, the operators reported a recovery of 2,322,000 tons of screenings and breeze. The yield of coke including breeze was 74.9 per cent. of the coal charged.

AVERAGE RECOVERY PER NET TON OF COAL CHARGED INTO BY-PRODUCT OVENS

	1918.	1919.	1920.
NH_3 (all forms) expressed in terms of equivalent ammonium sulphate, pounds	18.9	20.8	21.2
Tar, gallons	7.1	8.1	8.1
Crude light oil, gallons	2.4	2.7	2.5
Gas, M. cubic feet	10.4	11.6	10.8

[1] F. G. Tryon and W. F. McKenney, U. S. Geol. Surv.

World Production

According to the U. S. Geological Survey, reports received would indicate that the total output of 1920 was about 1,300,000,000 metric tons, or 1,430,000,000 short tons. Although a decided increase over the output of 1919, this lacked about 46,200,000 short tons of equaling the

BY-PRODUCTS OBTAINED FROM COKE-OVEN OPERATIONS IN THE UNITED STATES

Product.	Unit.	1919.			1920.(d)		
		Production.	Sales.	Value of Sales.	Production.	Sales.	Value of Sales.
Tar	gallons	288,898,764	217,080,143	$6,919,265	360,000,000	172,000,000	$7,400,000
Ammonia:							
Sulphate	pounds	544,231,985	557,619,631	21,075,718	675,000,000	629,000,000	27,150,000
Anhydrous ammonia(a)	pounds	50,535,639	51,646,744	5,692,950	65,000,000	63,000,000	8,300,000
Gas:							
Illuminating and household purposes	M. cu. ft.	.....	5,238,486	2,106,806	.....	24,000,000	2,150,000
Industrial purposes	M. cu. ft.	415,642,265	138,179,761	8,015,877	476,000,000	150,000,000	14,200,000
To public service corporations	M. cu. ft.	.....	49,655,732	6,562,324	.....	53,000,000	15,700,000
Bensol products:							
Crude light oil	gallons	92,356,750	.....	.....	109,000,000	843,000	96,000
Bensol—crude, including motor fuel	gallons	44,060,970	44,697,615	7,776,669	65,060,000	68,780,000	12,500,000
Toluol { refined	gallons	17,006,532	18,403,909	3,78355,2	16,890,000	15,580,000	4,030,000
Toluol { crude	gallons	.....	.....	.....	287,000	.....	.....
Toluol { refined	gallons	1,160,136	1,353,136	355,990	2,740,000	2,490,000	760,000
Solvent naphtha	gallons	3,915,489	3,625,978	552,853	5,420,000	4,530,000	820,000
Other refined oils	gallons	575,885	127,483	18,358	.....	.....	.....
Naphthalene { crude	pounds	3,549,998	4,038,455	82,244	10,710,000	10,750,000	290,000
Naphthalene { refined	pounds	2,763,271	2,663,585	109,120	3,450,000	3,700,000	200,000
Other products(b)	.....	.....	.....	645,142	.....	.....	30,000
Total	.....	.....	.....	$63,696,868(c)	.....	.....	$93,626,000

(a) Includes liquor sold by pound of NH_3. (b) Includes sodium ferrocyanide, retort carbon, residue, paint, sodium prussiate, crude heavy solvent, and ammonium chloride. (c) Does not include coke breeze, production of which amounted to 1,839,291 net tons, valued at $4,442,541, nor coke production, which amounted to 25,143,542 net tons, valued at $160,143,787. (d) Preliminary figures.

output of 1913, the last year before the war. The trend of production in metric tons during the past decade is shown in the following table.

THE WORLD'S PRODUCTION OF COAL, 1910–1920
(In metric tons)

Year.	Production (in Part Estimated).	Per Cent. Produced by United States.
1910	1,160,000,000	39.2
1911	1,189,000,000	37.9
1912	1,249,000,000	38.8
1913	1,341,000,000	38.5
1914	1,208,000,000	38.5
1915	1,190,000,000	40.5
1916	1,270,000,000	42.1
1917	1,336,000,000	44.2
1918	1,332,000,000	46.2
1919	1,170,000,000	42.1
1920	1,300,000,000	45.1

The fluctuations in world coal supply become somewhat clearer if expressed as index numbers, taking the output in the year 1913 as equal to 100. The production in the other years then becomes as follows:

1910	86	1916	97
1911	89	1917	100
1912	93	1918	99
1913	100	1919	86
1914	90	1920	97
1915	89		

These figures are necessarily in part estimated, for official statistics are slow in coming in and for certain countries of eastern Europe—notably Russia—even unofficial data are lacking. As official reports are available for 92 per cent. of the world's output, the margin of error in the total probably does not exceed 1 or 2 per cent.

In comparing the 1920 output with that of the years before the war it must be remembered that the world's consumption of coal normally increases rapidly. The average yearly rate of increase in the 20-year period preceding August, 1914, was 38,000,000 tons. Of course the waste and disorganization of the war have reduced the consuming capacity of many countries, but in others, notably the United States, requirements have been increasing at a rate greater if anything than before the war.

The present rate of production in the world is the resultant of conflicting forces: the decline in the war-torn countries is being offset in part by an increase in regions remote from the battlefields. In the belligerent countries of Europe the war cut heavily into production. Sometimes the cause of the decline was physical destruction of the mines, as in France; sometimes it was the drain upon the man-power of the nation; sometimes it was merely the economic disorganization and disruption of normal trade which attended the war. In France the 1920 output (excluding the Saar and Alsace-Lorraine) was 46 per cent. less than that of 1913; in Great Britain the decline was 20 per cent.; in Germany (also excluding the Saar and Alsace-Lorraine) the output of bituminous coal decreased 24 per cent., a decrease which was in part, however, offset by the increased production of lignite. In Eastern Europe—the old Austro-Hungarian Empire, Russia, and the Balkans, the breakdown caused by the war was even greater than in Western Europe, and the decline in output proportion-

ately large. Of all the major European belligerents only Belgium in 1920 had practically re-attained the pre-war rate of production.

To fill the void existing in Continental Europe and in the maritime markets formerly supplied by Britain and Germany, the outlying coal fields of the world increased their production greatly. The stimulus of demand was felt not only in the neutral countries of Europe—Spain, Holland, and Scandinavia—all of which developed their

PRODUCTION OF COAL BY CONTINENTS, 1913 AND 1920
(In short tons)

Continent.	1913.	1920.	Increase or Decrease.	Per Cent. of Change.
North America	584,760,000	666,430,000	+ 76,670,000	+13.1
South America	1,760,000	1,870,000	+ 110,000	+ 6.2
Europe	803,000,000	657,250,000	−145,750,000	−18.1
Asia	61,380,000	83,380,000	+ 22,000,000	+35.9
Africa	9,130,000	12,980,000	+ 3,850,000	+42.2
Oceanica	16,500,000	13,090,000	− 3,410,000	−20.7
World	1,476,530,000	1,435,000,000	− 46,530,000	− 3.2

THE WORLD'S PRODUCTION OF COAL IN SHORT TONS

Country.	1916.	1917.	1918.	1919.	1920.
United States	590,098,175	651,402,374	678,211,904	546,155,000	645,663,000
Canada	14,461,678	14,046,759	14,977,926	13,681,218	16,623,598
Mexico	.....	(a)450,000	(a)450,000	763,252	.....
Chile	1,563,000	.....	.....	1,693,245	.....
Peru	357,346	396,132	387,773	385,571	.....
Austria-Hungary	44,975,607	42,278,850	35,738,082	(h)32,381,165	(h)36,654,000
Belgium	16,458,816	18,587,942	15,308,301	20,378,474	24,707,000
France	23,670,000	31,847,000	30,864,000	24,776,140	27,862,069
Germany	(f)175,097,000	(f)184,427,000	(g)273,930,000	222,172,000	267,838,000
Great Britain	287,110,153	278,319,149	255,040,328	235,043,278	258,720,000
Holland	2,987,000	3,370,000	5,277,813	5,964,228	6,062,638
Italy	1,439,433	1,898,334	2,393,531	1,452,744	2,021,337
Russia	28,962,724	30,047,000	.....	.....	.....
Spain	6,005,727	6,261,124	7,897,319	6,882,220	6,526,157
Sweden	457,262	487,914	445,874	473,181	.....
China	(a)24,000,000	.....	.....	25,290,339	19,800,000
Dutch East Indies	.....	.....	.....	925,875	.....
India	19,324,826	20,398,468	23,209,104	25,344,465	.....
Japan	22,189,969	29,220,897	30,600,000	33,259,600	29,784,146
Rhodesia	491,532	614,856	550,243	571,269	647,939
Transvaal (b)	11,200,370	11,628,870	11,937,683	11,498,071	12,300,000
New South Wales	9,102,420	9,288,011	11,062,604	9,667,746	12,001,919
New Zealand	2,527,991	2,316,629	2,278,455	2,069,676	2,065,037
Queensland	1,016,654	1,174,290	1,101,176	1,043,470	1,243,155
Tasmania	62,244	71,021	67,386	74,207	84,484
Turkey	229,501	405,393	391,402	530,571	770,000
Western Australia	337,709	365,751	377,499	449,938	.....
Victoria	463,074	522,188	484,544	467,316	487,482
Total	(c)1,394,000,000	(c)1,470,000,000	(c)1,463,000,000	(c)1,233,000,000	(c)1,435,000,000

(a) Estimated. (b) Transvaal includes Natal and Cape of Good Hope and figures given are of coal sold only. (c) Approximate. (d) Hungarian production estimated at 10,000,000 short tons. (f) From *Glückauf;* does not include lignite. (g) Lignite production estim ated at 97,000,000 tons. (h) Czecho-Slovakia plus Austrian Republic.

scanty resources to the utmost, but extended to the Americas, Africa, and Asia. Japanese, Chinese, and East Indian mines took over the bunkering business relinquished by the British in the Far East. In the bitterness of Europe's need coal from the Appalachians was shipped through Trieste and Fiume to Austria, or carried up the

Rhine to Switzerland, passing within gun-shot of the great Ruhr field of Germany. Considerable tonnages were brought from South Africa, and a stray cargo from China found its way to Europe. Even the East Indies and far-away Spitzbergen felt the stimulus. The manner in which the outlying countries came to the assistance of Europe is shown in the accompanying table, which gives production, by continents, before and after the war. Only Oceanica, of the distant lands, produced less in 1920 than in 1913, and there, as in Europe, the cause was the disorganization of the war; for Australia and New Zealand both sent a large proportion of their able-bodied men to Europe and have not yet regained their pre-war productivity.

Thus, while in 1913 Europe led all the continents as a producer of coal, contributing 54 per cent. of the world's output, in 1920 she had yielded first place to North America and her share of the world's total had shrunk to 46 per cent. The largest factor in filling the void caused by the war was, of course, the United States. In 1920 our sea-borne exports of coal were 22,500,000 net tons, five times what they were in 1913.

Coal and Coke in Foreign Countries

Austria.[1]—According to figures issued by the Austrian Ministry of Commerce and Industry, Austria produced during the first 8 months of 1920 a total of 1,621,612 metric tons of coal, and imported 2,444,270 metric tons during this period. From the same source it is reported that of this domestic production 86,906 tons was hard coal, while the remaining 1,534,706 metric tons was soft, or brown, coal.

Therefore during the first eight months of 1920 Austria produced coal of both grades at the rate of 202,701 metric tons per month, and imported coal at the rate of 305,534 metric tons per month. The sum of these resources, 508,235 metric tons, is said to be under 50 per cent. of the actual need of Austrian industry.

The Austrian Ministry of Commerce and Industry estimates that to keep industry normally alive the monthly need of coal amounts to 1,222,480 metric tons—773,570 metric tons of hard coal, and 448,910 tons of brown coal. An average monthly shortage of 700,000 metric tons is reported.

It is interesting to note in this connection that an estimate made independently by Commercial Counsellor Oscar Berl, writing in *Das Handelsmuseum*, Sept. 2, 1920, under an itemized table of industrial needs, put the average monthly need at 1,248,839 metric tons of coal and coke. He estimates that 42 per cent. of this need is covered by supplies produced domestically or imported, mainly from Czecho-Slovakia, Upper Silesia, and Poland. He states that with an adequate supply of coal certain industries would be able to produce not only for domestic needs, but also for export.

The main Austrian mines now working are at St. Poelten, Wels, Leoben, Graz, Klagenfurt, and Hall in the Tyrol.

[1] *Comm. Rept.*, Feb. 19, 1921.

PRODUCTION OF COAL AND COKE IN AUSTRIA

Year.	Coal.		Lignite (Brown Coal).		Coke.
	Austrian Republic.	Old Empire.	Austrian Republic.	Old Empire.	Old Empire.
1911	84,686	14,379,817	2,566,349	25,265,334	2,057,911
1912	90,506	15,797,889	2,644,583	26,283,690	2,347,844
1913	87,517	16,459,889	2,659,582	27,378,332	2,598,782
1914	84,863	15,546,455	2,397,747	23,580,738	2,201,985
1915	76,424	16,083,075	2,485,627	22,017,151	1,907,619
1916	86,606	17,601,708	2,505,767	23,199,895	2,584,674
1917	88,850	16,729,172	2,212,229	21,625,949	2,618,485
1918	94,573	14,310,527	2,065,781	18,110,848	1,692,051
1919	89,792	.....	1,986,014	.....	.....

Belgium.—The coal production of Belgium in 1920 amounted to 98 per cent. of the production in 1913. The official figures given by *Annales des Mines de Belgique* show a total of 22,414,000 metric tons, compared with 18,487,230 tons in 1919. Imports of coal were 1,841,000 tons in 1920 against 133,000 tons in 1919, while exports totaled 2,120,000 tons against 4,112,000 tons. The production of coke amounted to 1,800,000 tons and of briquets, 2,922,000 tons. Prices of coal and miners' wages were both increased during the year.

The *Colliery Guardian* announces the creation by royal decree of a National Institute of Mines, at Frameries, with the object of studying all matters concerning the better utilization of Belgian mineral products, the improvement of mechanical appliances and methods of working in mines, as well as the amelioration of the conditions of labor in mines. The Fra-

COAL PRODUCTION OF BELGIUM
(Metric tons)

	Mons.	Centre.	Charleroi.	Namur.	Liége.	Limbourg.	Total.
1913	4,406,550	3,458,640	8,148,020	829,900	5,998,480	.....	22,841,590
1914	3,578,840	2,701,550	5,764,410	534,180	4,135,070	.....	16,714,050
1915	3,310,200	2,573,430	3,875,690	410,660	4,007,520	.....	14,177,500
1916	3,705,540	3,212,860	5,223,970	497,150	4,223,350	.....	16,862,870
1917	3,869,680	2,785,400	4,671,240	437,870	3,155,510	11,640	14,931,340
1918	3,281,720	2,559,610	4,493,630	374,440	3,112,530	65,670	13,887,600
1919	4,047,480	3,113,780	6,269,140	510,690	4,406,210	139,930	18,487,230
1920	5,032,000	3,804,000	7,309,000	606,000	5,417,000	246,000	22,414,000

COKE PRODUCTION OF BELGIUM
(Metric tons)

	Hainaut.[1]	Liége.	Other Provinces.	Total.
1913	2,200,180	877,130	445,690	3,523,000
1914	1,406,460	595,210	?	2,001,670
1915	424,460	90,140	.....	514,600
1916	667,530	124,820	.....	792,350
1917	648,210	27,830	.....	676,040
1918	509,150	13,060	.....	522,210
1919	704,000	53,000	.....	757,000
1920	1,480,000	320,000	.....	1,800,000

[1]Couchant de Mons, Centre, and Charleroi.

meries testing station is placed at the disposal of the institute, which will be required to submit reports to the Government and to carry out such researches as the latter may think fit.

Bulgaria.—The total coal production of Bulgaria in 1920 exceeded that of any previous year, except 1917, according to Consul Graham H. Kemper at Sofia. The State mine at Pernik furnished 670,342 tons of the total of 748,085 metric tons mined during the year.

Canada.—With an output of 16,623,598 short tons of coal, Canada in 1920 broke all previous production records. This compares with 13,681,218 short tons in 1919, an increase of 22 per cent. The previous high-record production year was 1913, when the total amounted to 15,532,878 short tons. Output includes waste and unmarketable slack.

Canada's total production of bituminous coal in 1920 was 13,123,670 tons; anthracite, 130,594 tons, and lignite, 3,714,304 tons. The production by provinces for the three grades of coal in 1920 was as follows:

Nova Scotia, bituminous, 6,412,382 tons; New Brunswick, bituminous, 170,930 tons; Saskatchewan, lignite, 335,389; Alberta, anthracite, 130,594 tons; bituminous, 3,445,347 tons; lignite, 3,378,915 tons; British Columbia and Yukon, bituminous, 3,095,011 tons.

By kinds of coal the increases in production for Canada were as follows: Anthracite, 0.3 per cent.; bituminous, 16.0 per cent.; and lignite, 5.6 per cent.

The number of men employed in underground work in Canadian mines by months for the five districts already named was as follows in 1920:

January, 22,642; February, 21,152; March, 19,762; April, 18,464; May, 18,691; June, 19,027; July, 19,390; August, 19,727; September, 20,418; October, 21,068; November, 22,926; and December, 22,848.

The total number of men employed in surface work in Canadian mines by months for the five provinces is given as follows:

January, 10,735; February, 10,557; March, 9,982; April, 9,804; May, 10,434; June, 11,684; July, 9,880; August, 11,203; September, 8,922; October, 11,801; November, 9,152; and December, 8,508.[1]

The total production of marketable coal during 1920 (comprising sales, colliery consumption and coal used in making coke, or used otherwise by colliery operators) was 16,623,598 short tons valued at $77,326,853, or an average of $4.65 per ton, and was the largest tonnage that has been obtained in any one year. The total production in 1919 was 13,681,218 tons valued at $54,413,349, compared with which the 1920 production shows an increase of 2,942,380 tons, or 21.5 per cent., and $22,913,504, or 42.1 per cent. in value.[2]

[1] *Coal Review*, Mar. 16, 1921.
[2] Prelim. Rept. Min. Prod. of Canada, 1920, Can. Dept. of Mines.

PRODUCTION[1] OF COAL IN CANADA
(In short tons)

	1918.		1919.		1920.	
	Production.	Average Value per Ton.	Production.	Average Value per Ton.	Production.	Average Value per Ton.
Nova Scotia	5,818,562	$3.63	5,720,373	$3.86	6,395,545	$4.44
New Brunswick	268,312	4.97	179,108	4.42	161,164	5.81
Saskatchewan	346,847	2.08	380,169	2.16	349,860	2.38
Alberta	5,972,816	3.44	4,964,535	3.69	6,859,346	4.40
British Columbia	2,568,589	4.47	2,435,933	5.10	2,856,920	5.61
Yukon Territory	2,900	4.00	1,100	4.00	763	5.81
Total	14,977,926	$3.68	13,681,218	$3.98	16,623,598	$4.65

[1] Production includes sales, colliery consumption, coal consumed by operators in making coke, or for other uses, but does not include waste and unmarketable slack.

The exports of coal in 1920 were 2,558,174 tons valued at $18,014,899, or an average of $7.04 per ton, as against exports in 1919 of 2,070,050 tons valued at $12,438,885, or an average of $6 per ton, showing an increase of 488,124 tons, or 23.6 per cent., in quantity.

The total imports of coal of all classes in 1920 "entered for consumption," as recorded by the Department of Customs, were 18,742,542 tons, valued at $98,033,598, as against imports in 1919 of 17,308,837 tons valued at $61,160,799. The record shows a slight decrease in the imports of anthracite coal, but an increase in the imports of bituminous coal.

IMPORTS OF COAL INTO CANADA

	1918.		1919.		1920.	
	Tons.	Average Value per Ton.	Tons.	Average Value per Ton.	Tons.	Average Value per Ton.
Bituminous, round and run-of-mine	13,656,360	$2.73	10,127,965	$2.44	11,548,475	$4.40
Bituminous slack	3,237,067	2.58	2,228,197	2.16	2,312,754	4.52
Anthracite coal and dust	4,785,160	5.44	4,952,675	6.38	4,881,313	7.53
Total	21,678,587	$3.30	17,308,837	$3.53	18,742,542	$5.32

The estimated consumption of coal based on production, exports and coal imported as entered for consumption, amounted in 1920 to 33,807,966 tons, as compared with a corresponding consumption in 1919 of 28,863,017 tons.

The total output of coke in 1920 was 1,306,644 short tons, from a total coal charge of 2,068,127 tons, of which 1,089,024 tons was imported. Sales were 135,818 tons; quantity used by operators 1,190,702 tons, giving a production of 1,326,520 tons valued at $14,509,074. The recovery of by-products at Sydney, N. S., Hamilton and Sault Ste. Marie, Ont., and at Anyox, B. C., included 14,026,172 gal. of tar and 19,142 tons of am-

monium sulphate. The corresponding figures for 1919 were: output of coke, 1,160,470 tons from a total coal charge of 1,880,541 tons; production, 1,133,680 tons valued at $9,720,387; tar, 12,394,249 gal.; and sulphate of ammonia, 11,765 tons. Of the 1919 output 1,036,229, or 89 per cent., was by-product coke, and 134,241 tons beehive coke.

Czecho-Slovakia.—Figures covering Czecho-Slovakian coal production and exports during the year 1920 show that the output has reached 82 per cent. of the 1913 figure. The amount raised during 1920 totaled 30,820,000 metric tons, as compared with 27,300,000 tons during 1919, of which 11,300,000 tons was bituminous coal (10,380,000 tons and 14,570,000 tons in 1919 and 1913, respectively), and 19,690,000 tons lignite (17,110,000 tons in 1919 and 22,600,000 tons in 1913). The share in tons of the various districts in the total output may be seen from the following table:

BITUMINOUS COAL

	1913.	1919.	1920.
Ostrau	9,800,000	6,800,000	7,480,000
Rossitz	510,000	380,000	390,000
Kladno	2,500,000	1,800,000	1,900,000
Pilsen	1,300,000	1,000,000	900,000
LIGNITE			
Bruex	18,500,000	13,100,000	14,770,000
Falkenau	4,100,000	3,700,000	4,400,000
Slovakia	200,000	150,000	200,000

Coke production is given at 1,470,000 tons in 1920; 1,390,000 tons in 1919; and 2,560,000 tons in 1913, while the respective figures for briquets are 160,000 tons and 70,000 tons. Subjoined are the export figures for the various countries:

EXPORTS OF COAL FROM CZECHO-SLOVAKIA
(In metric tons)

	1919.	1920.
Pit coal	1,068,335	1,134,124
Lignite	2,686,217	3,426,851
Coke	188,621	273,650
Briquets	.....	52,158

DESTINATION OF EXPORTS IN 1920

	Pit Coal.	Lignite.	Coke.	Briquets.
Germany	28,000	2,368,000	.....	40,000
Austria	522,000	1,059,000	142,000	12,000
Poland	570,000	.....	4,000	.....
Jugo-Slavia	7,000	.....	4,000	.....
Hungary	5,000	.....	5,000	.....
Roumania	1,000	.....	4,000	.....
Italy	.....	.....	1,500	.....

France.—The following figures of France's production of coal in 1919 and 1920 are furnished by the French Minister of Industry. The figures are in metric tons and are exclusive of lignite.

	1919.	1920.
French production	17,945,821	20,348,020
Sarre production	2,503,354	4,478,703
Imported from Germany	1,030,500	6,959,656
Imported from other countries	17,801,377	17,122,831
Totals	39,281,052	48,909,210

On Jan. 1, 1920, there were stocks on hand of 1,500,000 tons. On Jan. 1, 1921, stocks on hand totaled 4,500,000 tons.

The price of coal in France has varied as follows:

January, 1920.	Frs. per Ton.	January, 1921.	Frs. per Ton.
French coal	122	French coal	124
Sarre coal	125	Sarre coal	110
German coal	125	German coal	125
Belgian coal	78	Belgian coal	134
English coal	304	English coal	196
American coal	313	American coal	195

French production of coal, including lignite, in 1920, amounted to 25,276,304 metric tons, against 22,476,766 tons in 1919. The output of the Sarre mines, including lignite, was 9,410,433 tons in 1920.

The coal resources of France contained in deposits lying at a depth of not more than 3,937 feet are estimated at 13,143,000,000 tons and at a depth of 5,905 feet at 17,600,000,000 tons.

France's production of coal in 1913 was 40,844,000 metric tons and consumption 64,834,000 tons, the additional 23,990,000 tons being imported from England, Belgium, and Germany. The future estimated French deficit of coal, due to the return of Alsace-Lorraine and the increased industrial activities, is estimated at over 40,000,000 tons.

The total production of coal in France during the past eight years is given below:

	Tons.		Tons.
1913	40,844,218	1917	28,891,723
1914	26,568,258	1918	25,000,000
1915	19,523,863	1919	22,476,766
1916	21,310,000	1920	25,274,304

The production of coke during 1920 was 782,334 tons and that of briquets 2,058,497 tons.

Imports of coal, coke, and briquets reached the record figures of 32,456,922 metric tons in 1920, as compared with 22,092,879 tons in 1919, and 22,866,967 tons in 1913, while only 470,000 tons was re-exported or exported as compared with 1,740,000 tons in 1913, thus leaving an available surplus of imports in 1920, as compared with 1913, of about 10,000,000 tons, which offset to a considerable extent the losses experienced in home production through the destruction, whole or partial, of the mines in northern France.

The importance of the French coal mines destroyed or damaged as a result of the war should be emphasized. In 1913, 20,928,275 tons, or approximately one-half of all the coal produced in France, came from those mines. The production of the devastated mines, however, has shown a large and steady improvement. From 1535 tons in January,

1919, it increased to 122,055 tons in January, 1920, and to 353,297 tons in January, 1921. The production for January, 1921, represents a proportion of 24 per cent. of the production before the war of the devastated mines, not including Bethune, where reconstruction work is greatly advanced. From the mines in the Department of Nord the January, 1921, production corresponds to 43.5 per cent. of the pre-war production. This percentage will probably be increased to 66 per cent. toward the end of 1921, provided that sufficient labor can be recruited. French coal mining has been greatly handicapped from shortage of labor since the war. Reconstruction will take far longer in the Department of Pas-de-Calais, due to the immense damage done to the mines there.

The Minister of the Liberated Regions has stated that when the French recovered possession of the mines in the Departments of Nord and Pas-de-Calais, 140 mine-shafts were found totally destroyed and the workings flooded, 2800 kilometers of gallery had to be re-established, and a volume of water extracted estimated at 110,000,000 cu. meters. There were 18,000 miners' dwellings completely destroyed and 12,000 partly demolished. Power-plants with a capacity of 383,000 hp. were destroyed. It is estimated that the total cost of reconstructing the destroyed mines will be from four to five billion francs, and it will require nearly 10 years before the output can be on a pre-war basis. In spite of the admirable work already done, thousands of dwellings must still be constructed, and about 100,000,000 cu. meters of water remain to be pumped out. A loan is being floated for reconstruction the devastated mines.

The treaty of Versailles has placed the Sarre territory, for a period of 15 years, under the control of the League of Nations which delegates its administration to a commission of five members, designated by the League for a period of one year with possibility of renomination. These five members are selected as follows: One French, one native of and living in the Sarre territory and not of French nationality, three members from any country other than France and Germany.

After the expiration of a period of 15 years, the Sarre population will be called to express its wishes by a plebiscite as to whether it desires annexation to France, annexation to Germany, or independence.

The French Government assumed possession of the Sarre mines as of Jan. 18, 1920. Shortly after that date, a projected law was presented to the Chamber of Deputies by the French Government with the end in view of instituting an "Office des Mines Domaniales de la Sarre" which would exploit the Sarre mines and would be a public institution with civil rights and financial independence. Until this project is passed, the Sarre mines are under a provisional status as outlined in a decree of Oct. 23, 1919.

From 1900 to 1913, the production of the Sarre mines only increased from 10,000,000 to 13,000,000 tons, whereas the production of all coal mines of the German Empire increased from 96,000,000 to 191,000,000 tons.

It has been said that the coal mined in the Sarre region could not be used to produce metallurgical coke. However, in 1913, 2,000,000 tons of such coke was produced in the Sarre basin.

By the terms of the peace treaty there must be left in the Sarre territory for local consumption a part of the production of the mines at least equal to that of 1913, which represented 43 per cent. of the total production.

In 1913, the production of the Sarre mines was estimated as 13,216,309 tons, a monthly average of 1,101,359 tons. In 1919, the last year of the German exploitation of the mines, 8,981,299 tons, was extracted, or 748,441 tons per month, and during 1920, 9,410,433 tons, or 784, 203 tons per month. The 8-hr. day law introduced during 1919 adversely affected the production during the latter part of the year. At the end of 1919, there were 63,100 registered workers in the Sarre mines.

The provisional status of the mines is said to have given satisfactory results and it is thought that the ultimate organization should not materially differ, but should only amplify it and eliminate the necessity for public accounting. According to a program fixed by the engineers of the Sarre mines, 150,000,000 francs at least will be needed for the completion of the works.[1]

Germany.[2]—The following table gives the figures of the various coal-producing sections in thousands of metric tons for the year 1920:

	Bituminous Coal.	Brown Coal.	Coke.	Coal Bricks.	Brown Coal Bricks.
Prussia exclusive of the Saar and Palatinate districts	127,036	91,761	24,865	4,177	19,837
Bavaria	87	2,421	.....	.....	121
Saxony	4,056	7,656	145	.....	1,808
Badenia	.....	.....	.....	669	.....
Hessen	.....	522	.....	82	18
Brunswick	.....	2,756	.....	.....	624
Saxony-Altenburg	.....	5,364	.....	.....	1,715
Anhalt	.....	1,154	.....	.....	158
Other provinces	168	.....	168	11	.....
Total Germany without Saar and Palatinate districts	131,347	111,634	25,177	4,938	24,287

Total production of coal of all kinds is thus 272,206,000 tons.

These figures denote considerable progress compared with 1919, and

[1] Consul Frank L. Ives, Paris, *Comm. Rept.*, June 6, 1921.
[2] H. O. Herzog, Berlin, *Coal Age.*

even make quite a good showing in comparison with the production of bituminous coal during war-time, as is shown in the following tables:

	Total Germany.	Total Excluding Alsace-Lorraine (Saar and Bavarian Palatinate)
	In Thousands of Metric Tons.	
1914	161,535	148,523
1915	146,712	134,352
1916	158,847	145,111
1917	167,311	154,409
1918	160,526	148,187
1919	116,681	107,711
1920	131,347	131,347

For comparison the first row of figures of the above table gives the output of the German state including the territories disannexed by the peace treaty, while in the second row the output of the latter has been deducted. These figures demonstrate the progress in 1920 and the approach to normal conditions.

When making comparison with the production of pre-war years German publications invariably put forward the output of the year 1913. The output of 1920 remains far behind that of 1913, but the latter year represents the highest German coal production on record, and gives by no means a fair standard. In fact production in 1920 does not fall so very short of pre-war production, when looking back beyond 1913. Production in the years from 1908 to 1913, inclusive of the contribution of the now disannexed districts, was as follows in metric tons: 1908, 146,093,000; 1909, 146,964,000; 1910, 151,073,000; 1911, 158,581,000; 1912, 174,875,000; 1913, 191,511,000. The contribution of the disannexed districts averaged 8 per cent. of the total output, which should be deducted when considering the past output of the mines of present Germany only.

From these figures it appears that production now stands approximately where it was in 1909 and even 1910.

The increase in production is due to improvement of mine equipment, which, although carried out on a small scale, has made itself felt in such a way that in some mines the best record figures have already been reached; also to an increase in the number of miners, and mainly to the so-called overtime shifts or extension of regular working time from 7 to 8 or 8½ hours, which has come into force since March, 1919, although results were delayed by the political riots of that month. How far the larger number of miners is responsible for increased production becomes apparent in the following figures relating to the Rhenish-Westphalian district:

1920, Month.	Output per Day, Metric Tons.	Number of Work Days.	Number Employed.	Production per Man and Shift.
January	264,875	25¼	475,747	0.591
February	286,511	24	479,252	0.613
March	236,951	27	481,274	0.581
April	271,314	24	474,202	0.580
May	305,053	23¼	479,080	0.593
June	304,272	24½	484,410	0.591
July	280,154	27	491,106	0.577
August	287,879	26	502,526	0.574
September	300,042	26	511,274	0.578
October	312,199	26	519,685	0.607
November	331,205	24¼	527,348	0.628
December	377,279	24⅝	532,798	0.720

The most adverse condition is the general deficiency of transportation. The Ruhr district alone reports for December a shortage of 122,000 trucks. The stores of coal at pit mouths in the district increased from 490,000 tons to 882,000 tons in December, compelling several mines to reduce shifts.

While coal production has improved, it is still below the average of previous years; but brown coal production has reached unparalleled figures.

Consul General William Coffin, with the American Commission at Berlin, reports that the *Industrie und Handels Zeitung* has published figures concerning the increase in lignite fuel used in Germany, an increase due to the shortage of other coals.[1] The following figures show the production of lignite in Germany in metric tons.

	1897.	1900.	1913.	1917.	1918.	1919.	1920.
Lignite	29,420,000	40,500,000	87,200,000	95,500,000	100,600,000	93,800,000	111,600,000
Briquets	3,939,000	6,505,000	21,392,000	22,030,000	23,100,000	19,400,000	24,300,000

At the outbreak of the war the production fell off very considerably, to recommence in 1915, when it attained practically the same figures as in 1913. The introduction of the 8-hr. day in lignite mines has necessitated a large augmentation in the employ of miners, an addition estimated to be at least 50 per cent.

Great Britain.—British coal output for the year 1920 approximated 231,000,000 long tons, as compared with 229,000,000 tons in 1919. From Nov. 13 to Dec. 18, the test period of output to determine miners' rights to higher wages, the weekly production averaged 5,215,160 tons, or at the rate of 260,758,000 tons per year. The output is steadily gaining.

Holland.[2]—The output of the Limburg mines during the year was larger than anticipated and increased over 1919 by 538,049 metric tons or, including slack coal, 575,574 tons. The total production is returned at

[1] *Comm. Rept.*, Apr. 30, 1921.

[2] *Comm. Rept.*, July 12, 1921.

3,940,595 tons or, including slack coal, 3,977,120 tons as compared with 3,401,546 tons the previous year.

The production of lignite decreased and the end of the production of any lignite in the Netherlands is in sight. The total production in 1920 amounted to 1,395,851 tons as compared with 1,881,962 tons in 1919. Several lignite mines have been completely exhausted and the last mine of any considerable importance contains only about 600,000 tons, which will be exhausted in the current year.

Imports of coal from the United States into the Netherlands were greatly increased during the year, but the increase was mostly at the expense of Belgium and Great Britain. There was a decrease in total imports from 3,616,685 metric tons in 1919 to 3,327,173 tons in 1920; these figures include coke and briquets.

India.[1]—According to the report of the Department of Statistics, India, on the production and consumption of coal for 1919, the country's total production in that year amounted to 22,630,000 long tons, of which 98.3 per cent. was obtained from the Gondwana system of strata (chiefly composed of sandstone and shales deposited in fresh water and by rivers). British Provinces are credited with the production of 21,770,000 tons, of which Bihar and Orissa produced 15,120,000 tons and Bengal 5,780,000 tons. Thus the output of these two Provinces alone amounted to 92.5 per cent. of India's total, 87 per cent. of the total being derived from the two fields in Damodar Valley, Jherria producing 12,146,000 tons and Raniganj producing 6,815,000 tons. The Native States produced only 860,000 tons, of which 660,000 tons is credited to Hyderabad. The production, net imports, and the exports from 1913 to 1919 are given in the following table:

Year.	Production.	Net Imports.	Exports.	Year.	Production.	Net Imports.	Exports.
	Tons.	*Tons.*	*Tons.*		*Tons.*	*Tons.*	*Tons.*
1913	16,208,009	644,879	759,155	1917	18,212,918	43,720	408,117
1914	16,464,263	418,741	579,746	1918	20,722,493	54,346	74,466
1915	17,103,932	190,591	753,042	1919	22,628,037	48,577	508,537
1916	17,254,309	33,320	881,741				

The following statement shows the output of coal in the various Provinces of British India during 1920:

	Long Tons.
Assam	324,965
Baluchistan	27,672
Bengal	4,207,452
Bihar and Orissa	11,973,339
Central Provinces	491,205
Punjab	58,078
Total	17,082,711

[1] *Comm. Rept.*, June 13, July 16, 1921.

The 1920 output is the lowest since 1914—the effect, no doubt, of labor unrest in the coal fields.

Jugo-Slavia.[1]—Coal mines are widely distributed throughout the Kingdom of the Serbs, Croats, and Slovenes, the chief centers of production being the region just north of Zagreb, the region north of Serajevo, the region around Petchoui, Baranya, and the northeastern section of Serbia proper. Practically all of the coal is either brown coal or lignite, none of which is suitable for the production of coke.

There has been no careful survey of the coal-producing possibilities of the country, but they are believed to be enormous. The following table gives the production of coal, by Provinces, for the years 1913 and 1919; in metric tons:

Provinces.	1913.	1919.
	Tons.	*Tons.*
Serbia	311,365	103,730
Bosnia Herzegovina	800,000	674,930
Croatia Salvonia	205,000	251,293
Slovenia	1,471,067	1,153,338
Baranya (Petchoui)	700,000	310,767
Total	3,847,432	2,494,058

The output in the mines in the Kingdom is being greatly handicapped by a lack of transportation and practically all of the mines have been obliged to curtail their production, as the railway facilities were inadequate to handle their total output.

Importation of coal to meet the internal demands of the country would not effect the situation, as the difficulties of transportation would likewise prevail in the carrying of coal from Saloniki, Ragusa, or Spalato to the interior points for distribution. There is no exportation of coal.

Several new mines have started extraction in Bosnia and Herzegovina.

Malaya.[2]—Some years before the war broke out coal was discovered in the Malay Peninsula, in the States of Perak and Selangor. The coal found at Rawang, in Selangor, some 25 miles from Kuala Lumpur, proved to be of first-rate quality, and as prospecting proved the existence of a supply of over 10,000,000 tons, the Malayan Collieries Co., Ltd., was formed to work it and place it on the market. The difficulty of getting equipment during the war hindered development, but mining was started in earnest in 1915, when 11,523 tons of coal was obtained. Down to the end of 1918—the latest year for which figures are obtainable—437,388 tons had been mined, and the quantity would have been greater but for lack of equipment, shortness of labor, etc. The output in 1916 was 101,846 tons; in 1917, 155,279 tons; and in 1918, 168,740 tons. The

[1] *Comm. Rept.*, Aug. 27, 1920.

[2] *Comm. Rept.*, Mar. 11, 1921.

discovery of coal is likely to have an important bearing on local industries which hitherto have had to rely mainly on fuel supplies from the native forests.

New South Wales.[1]—The total coal output of New South Wales, Australia, for the year 1920 was 10,715,999 long tons, an increase of 2,084,445 tons over 1919. But for industrial troubles the output would have been 1,000,000 tons greater. There was also an increase in the coke production of the State of 142,796 tons over the figures for 1919.

Peru.[2]—Peru's coal production from 1906 to 1919 was as follows:

Years.	Long Tons.	Value.	Years.	Long Tons.	Value.
1906	79,969	$672,262	1913	273,945	$969,550
1907	185,565	521,226	1914	283,860	998,342
1908	311,122	685,054	1915	290,743	1,016,458
1909	321,502	936,004	1916	319,063	772,180
1910	307,320	870,877	1917	353,595	984,455
1911	324,000	944,758	1918	346,226	1,108,061
1912	278,927	877,466	1919	344,260	1,283,981

Of the total production 95.77 per cent. comes from the Department of Junin. In 1918 the Sindicato Carbonifero de Huayday was formed in Lima to exploit coal deposits in the Department of La Libertad. Huayday is one of the best anthracite deposits of Peru and it is estimated that there are several million tons of good coal there. The Provinces of the Department of Junin which produce coal are Cerro de Pasco, Yauri, and Huancayo. In the Province of Cerro de Pasco there are four distinct regions exploited, viz., Goyllarisquizga, Quishuarcancha, Yanahuanca, and Santo Domingo, the first two being the most important.

It is reported that the large deposits back of the port of Chimbote in the Department of Ancachs contain coal of a very good quality. There are also large coal deposits in the Province of Moquegua, near Carumas, but in both of these cases it would require a great deal of capital to construct railroads from the coast to the mines and to work the mines on a scale large enough to make it worth while. Chimbote Harbor is one of the best in the country and well suited for a coaling station; it lies about one-third the distance between the Canal Zone and Valparaiso.

During the past nine years approximately 82 per cent. of all the coal produced and imported into the country has been used by the mining industry.

Philippine Islands.[3]—The management of the National Coal Co. organized by the Philippine Government reports that the company is now prepared to market 2500 tons of good steaming coal monthly. It has been operating three years, during which time its efforts have been directed toward developing the coal deposit at Butong, Zamboanga Prov-

[1] *Comm. Rept.*, June 24, 1921. [2] *Comm. Rept.*, Apr. 29, 1921. [3] *Comm. Rept.*, Apr. 8, 1921.

ince, and the one situated near Cebu. At Butong a shaft has been sunk 42 meters into a vein of semi-anthracite coal said to be about 8 ft. thick. Engineers in charge of operations say that indications are that the vein extends under an entire mountain and contains large quantities of coal of excellent quality. Most of the coal produced by the company is taken from this vein, but there are other outcroppings on the Zamboanga Peninsula, on the Sibuguey Gulf, that are being worked. Some coal is also being mined under contract at the Campostela mine near Cebu.

Poland.—According to information furnished by the Polish Legation in Washington, the total amount of coal produced in Poland in 1920 was 6,658,347 metric tons, of which 5,114,905 tons were from the Dombrowa Basin and 1,543,442 tons from Galicia. The mines of the Dombrowa furnished pit coal to the amount of 4,873,437 tons and brown coal to the amount of 241,468 tons, while Galicia furnished 1,532,982 tons of pit coal and 10,640 tons of brown coal. The total production in 1919 was 6,145,027 tons, and in 1913, 8,988,580 tons.

Queensland.[1]—The total quantity of coal raised in Queensland in 1920 was 1,109,913 long tons of the value of £841,551, this being, as compared with the 1919 yield, as increase of 178,282 tons in quantity and £227,244 in value.

The average cost per ton of the coal output at the pit's mouth for the whole State for 1920 (15s. 1.9d.) was 1s. 11.7d. higher than in the preceding year. The increased production was distributed over all the coal-producing districts of the State except one (Maryborough), where there was a slight falling-off in output, although an improvement in the value of the product. Of the total yield Ipswich turned out 763,590 tons, nearly 143,000 tons more than for the year 1919; Darling Downs showed an improvement of over 4600 tons, Rockhampton of 2172 tons, and Clermont of 23,751 tons. The State Colliery at the Bowen River had an output from shaft sinking of 3914 tons, as against only 306 tons for the preceding year, while the yield of Mount Mulligan, in the far North, increased from 19,998 tons in 1919 to 23,642 tons for last year.

Spain.—Statistics on the coal production in Spain for 1920 show a total output for the year of 5,920,491 metric tons. Of this amount 263,338 tons were anthracite, 552,866 tons lignite, and 5,104,287 tons pit coal. The total production falls about 1,000,000 tons short of the amount required for Spanish industry.

The annual production of coal in the 7 years immediately preceding the war increased steadily, anthracite at the rate of 9000 tons per year, lignite at the rate of 12,000 tons per year, and bituminous coal at the rate of 36,000 tons per year.

[1] *Queens. Govt. Min. Jour.*, Apr. 15, 1921.

PRODUCTION OF COAL IN SPAIN

Year.	Production, Metric Tons.				Imports, Metric Tons.
	Anthracite.	Bituminous.	Lignite.	Total.	
1913	232,500	3,783,200	276,700	4,292,400	3,098,300
1914	228,300	3,905,100	291,100	4,244,500	2,875,800
1915	222,600	4,135,900	328,200	4,686,700	1,905,000
1916	268,100	4,847,500	473,100	5,588,700	2,151,200
1917	310,900	5,024,800	636,800	5,972,500	1,167,300
1918	617,200	5,761,000	785,600	7,164,400	528,100
1919	398,771	5,304,866	539,872	6,243,509	.....
1920	263,338	5,104,287	552,866	5,920,491	.....

Spitzbergen and Norway.[1]—Norway proper is a country entirely without coal deposits. However, since the title to the island of Spitzbergen has been turned over to Norway, the coal deposits of the island are to be considered as part of the country's national fuel assets.

Norway imported 2,482,424 tons of coal, coke, and briquets in 1913, 2,276,808 tons of which were unmodified mineral coal and the remainder coke and briquets. In 1919, as a result of high prices and export restrictions on the part of exporting countries, the importation fell to 1,739,970 tons, of which 1,547,886 tons was coal.

The Tertiary strata which contain the steam-coal in Spitzbergen are the most remarkable geological feature of the country. The coal can be won from them very cheaply. The seams are not worked by pits, but by adits, or tunnels into the hillside, the coal being transported to the ships at the wharves by gravity ropeway, the sea margin of the coal being within a few hundred yards of deep water. The Spitzbergen steam-coal fields are estimated to cover more than 500 square miles and to contain more than 200,000,000 tons. The coal is said to be fully equal to the finest Welsh. The fields of household coal are much larger, but their total area has not yet been proved.

The sovereignty of the islands has been awarded to Norway by the League of Nations. More than three-fourths of the proved mineral areas, however, are owned by British interests.

The director of the Swedish coal fields in Spitzbergen confirms the statement regarding newly discovered coal deposits on that island. It appears that these have been found at a depth of 26 ft. below what has heretofore been considered as the bottom of the Svea mine. The vein recently opened, according to the director, has an average thickness of over 6 ft., with an estimated area of about 16,000,000 sq. ft.

Sweden.[2]—The imports of coal into Sweden in 1920 amounted to 2,811,633 metric tons as compared with 1,930,514 tons in 1919 and 4,878,854 tons in 1913. Owing to the small quantity of coal imported

[1] *Comm. Rept.*, July 23, Aug. 9., Oct. 13, 1920. [2] *Comm. Rept.*, Apr. 28, 1921.

in 1917, 1918, and 1919, Sweden suffered from a serious scarcity, the domestic production from the mines in Scania, in the southern part of the country, being relatively of little importance. The shortage was not fully realized until 1920 was well advanced.

In 1919 the share of the United States in the Swedish coal import was a little over 11 per cent., while in 1920 it had risen to over 44 per cent. It is to be observed that while the amount of American coal imported in 1920 showed a very satisfactory increase in July, August, and September, October brought a decrease which became more and more pronounced toward the close of the year. American coal never figured in Swedish statistics until 1918, for, up to that, the quantity was so small as to be included under "other countries."

The following table shows the production and imports of coal and coke in Sweden, in metric tons:

Years.	Production.		Imports.	
	Coal.	Coke.	Coal.	Coke.
1911–1913 (average)	345,355	52,319	4,379,181	432,620
1914	366,639	154,864	4,626,932	449,576
1915	412,261	164,461	3,835,687	1,220,446
1916	414,825	181,247	4,036,452	1,296,161
1917	442,633	122,924	1,503,757	520,311
1918	404,494	.....	1,976,711	524,424
1919	429,267	.....	1,942,962	279,147
1920	.....	.....	2,811,633	.....

The export of coal from Sweden was restricted during the war, and the restriction still exists. Special permission has been given from time to time to ship coal out of the country.

Turkey.[1]—The coal production in Turkey for recent years is given in the following table in metric tons:

Year.	Coal.	Coal Dust.	Lignite.	Year.	Coal.	Coal Dust.	Lignite.
1911	857,850	45,934	38,375	1916	208,203	(a)	.....
1912	758,716	51,470	19,839	1917	172,193	(a)	195,568
1913	800,283	26,536	15,651	1918	200,306	(a)	154,771
1914	636,502	14,736	9,834	1919	481,331	(a)	.....
1915	415,854	4,469	76,252				

(a) Coal dust was classified with coal after 1915.

Coal is found in the Heraclea Basin, which extends along the Black Sea coast from Akdje-Shehir to Couroudja-Chile-Capou-Sayan (150 kilometers) near Djideh. It penetrates about 20 kilometers to the interior. The coal area is said to be much larger than the aforementioned.

[1] Consul General G. B. Raondal, Constantinople, *Comm. Rept.*, Jan. 29, 1921.

Coal and coal dust are extracted exclusively from this basin. There are also some coal regions in the vilayet of Castamoni at Djideh, Dadai, and Inebolou, where many concessions have been granted to several firms. But no serious exploitation exists outside of the Heraclea Basin. Other unexploited coal regions exist in many parts of Asia Minor.

Turkey is rich in lignite. The qualities vary from the most recent veins, where the structure of wood is apparent, like the lignite of Aghatchli, near Constantinople, to the oldest, closely resembling coal, like that of Soma and Kirmasti. The exploitation of these mines before the war was insignificant, but during hostilities it was quite extensive, due to the lack of fuel. Soma produced about 500 tons per day, Tekfour-Dagh 100 tons, Nazilli 100 tons, and Aghatchli 800 tons. Castambol is at present exploited by the Société des Chemins de fer de Roumelie. The best quality of lignite is that of Soma and Kirmasti.

Union of South Africa.—There are coal deposits of great extent and value in South Africa, and the industry is at present in excellent condition. The following figures[1] show the trend for the past four years, in long tons sold.

Year.	Transvaal, Tons Sold.	Natal, Tons Sold.	Union of South Africa.	
			Tons Sold.	Value.
1917	6,641,229	2,890,296	10,382,920	£3,275,608
1918	6,438,961	2,607,133	9,877,325	3,244,596
1919	6,622,313	2,801,004	10,266,135	3,416,244
1920	7,180,124	3,321,594	11,473,452	4,506,572

This compares with a production of 8,117,078 tons valued at £1,999,378 for the Union in 1913.

The Report of the Coal Commission states that amongst the mineral products of the Union it comes after gold and diamonds, and with large industrial expansion in Africa it may ultimately become of more value than either. It is roughly estimated that the coal resources of the Union amount to 56,200 million tons. Twenty years ago the export and bunker trade only absorbed 359,576 tons; last year the total was 2,897,412 tons. Last year the railways drew £5,201,183 in revenue from the trade, the collieries receiving only £4,506,572 in revenue. Thus the railways obtained more money for carrying coal than the companies received for mining it. The Commission is of opinion that the outlook for an expansion of the trade is good. The East African ports, Aden and Colombo ought to be supplied from the Union, while a share of business at Singapore and other Eastern ports and also South America may reasonably be looked for.[1]

[1] *So. Afr. Min. Eng. Jour.*, July 2, 1921.

COBALT

By C. W. Drury

A report of the discovery of a deposit of cobalt near Schwyn, Cloncurry District, Queensland, is recorded during the year 1920.[1]

The ore occurs on the contact of diorite and schist. The workings at present consist of four shafts, the deepest of which is about 30 ft. The ore consists of cobaltite and erythrite. A picked sample assayed for the Department of Mines, Queensland, gave the following composition:

	Per Cent.
Arsenic	40.2
Sulphur	15.8
Cobalt	33.1
Nickel	*Nil.*
Iron	2.1
Insoluble (chiefly SiO_2)	8.3

The average cobalt content of the ore is stated to be about 4 per cent., but no definite statement has appeared regarding the extent of the deposit.

A deposit of cobalt has been discovered recently, or perhaps rediscovered, in the Peak district of Derbyshire. However, cobalt has been found in Cornwall for centuries occurring in tin or copper lodes and associated with arsenic. The deposit in the Peak district is small and is not of sufficient size to be a large producer.

The following figures show the Canadian production in 1918, 1919, and 1920.

PRODUCTION OF COBALT IN CANADA, IN POUNDS

	1918.	1919.	1920.
Cobalt oxide	1,176,166	784,730	762,434
Cobalt metal	473,463	151,446	227,626
Cobalt sulphate	43,097	57,103	1,717

Cobalt metal, it should be noted, is produced from the oxide.

The Ontario smelters did not run to capacity through the year 1920, due to the decreased demand for the metal and different products.

The shipments of cobalt products from the mines at Cobalt for 1920 were 987,441 lb. of cobalt, for which $564,974 was received.

The Missouri Cobalt Co., Fredericktown, Mo., continued operations throughout the greater part of the year 1920. At present very little cobalt oxide is being produced, but the plant will run to capacity as soon as the demand for cobalt returns. The recovery in 1920 amounted to 102,410 lb. of cobalt oxide and cobalt hydrate, valued at $262,801.

[1] *Queens. Govt. Min. Jour.*, Nov. 15, 1920; Jan. 15, 1921.

Trade.—During 1920 the price of cobalt oxide varied from $2.00 to $4.10 and during the same period the metal sold for $3.00 to $6.00 per lb. With the return to normal prices for chemicals the cost of producing cobalt oxide will no doubt decrease.

IMPORTS INTO THE UNITED STATES OF COBALT PRODUCTS, COBALT, COBALT ORE AND ZAFFER, IN POUNDS
(Fiscal years ending June 30)

From	1914.	1915.	1916.	1917.	1918. (a)	1919. (a)	1920. (a)
Belgium	1,245	.....	.....	.....	.....	.....	.....
France	1,102	.....	.....	.....	.....	.....	.....
Germany	41,941	1,761	.....	.....	.....	.....	220
England	4,240	.....	.....	.....	.....	2,586	50
Canada	148,481	22,334	144,270	138,260	504,401	74,970	157,142
Total	197,009	24,095	144,270	138,260	504,401	77,556	157,412
Imports of cobalt oxide	109,484	190,145	238,934	236,822	208,596	131,424	202,704

(a) Calendar years.

Uses.—Cobalt is used as metal in the steel and alloy trade, as oxide and other compounds in the ceramic industries, and as linoleate, resinate, acetate, etc., in the paint and varnish industries. Owing to the more rapid rate of drying, the demand for cobalt products in the drying oil industries is increasing. Salts of cobalt are also used in printing. The fact that the inks dry faster permits greater speed in printing.

Owing to the increased price of cobalt during the year due to the high cost of fuel, chemicals and operations, considerable activity was shown in working old deposits. Some cobalt was produced in Norway[1] and the raw cobalt material was supposed to come from old deposits in Germany.

There is considerable difficulty in recovering cobalt from its ores and products. The high degree of purity demanded by the consumers necessitates careful chemical operations and re-precipitations. The increased price of cobalt has led several investigators to try new methods[2] of recovering this metal. A patent has been granted to M. J. Udy for precipitating cobalt as a basic insoluble sulphate. The cobalt is then recovered by electrolysis using insoluble anodes. There is no record of any cobalt being produced by such a method.

A patent[3] has been granted to the General Electric Co. covering a ductile nickel-cobalt alloy. An alloy containing 20 to 30 parts by weight of cobalt and 80 to 70 parts of nickel is produced in an electric furnace of the Coolidge type in an alundum crucible, special precautions being taken to prevent contamination with carbon, sulphur, etc., and when

[1] *Metal Bull.*, Nov. 26, 1920.
[2] U. S. Patent No. 1,336,765, Apr. 13, 1920.
[3] U. S. Patent No. 1,342,993, June 8, 1920.

melted about 2 parts of manganese is added. The alloy may be rolled from 0.5 in. to 0.02 in. without intermediate annealing and is particularly suitable as a supporting and current-lead wire for electric incandescent lamps, as it has but slight tendency to volatilize and spatter electrically. It has a low heat conductivity and therefore increases the efficiency of electric lamps, particularly in the case of miniature low-voltage lamps.

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COPPER

By Walter Harvey Weed

The year 1920 began with large sales and home deliveries, but as a whole proved a disappointing one for the copper mining industry. Beginning the year with record-breaking sales for domestic consumption of 130,000,000 lb. a month, and of export sales for the first half of the year amounting to 412,348,826 lb., it was felt that the long expected post-war demand had materialized. This auspicious beginning, however, was not maintained. In the second quarter of the year, domestic sales decreased to 215,000,000 lb., compared with 600,000,000 lb. for the first three months of the year, and experienced operators began to realize the danger of keeping the production of mines and smelters at so high a rate. In the last half of the year total sales for foreign and domestic account did not absorb production and unsold copper accumulated in the producers' hands. It was the beginning of the present unprecedented period of depression, in which mines are closed down, and smelters idle or almost so, a period of idleness from which the entire industry will suffer, even when a strong demand for the metal brings about a revival of the business.

The producers endeavored to stimulate sales by a slow reduction of prices, from 19 cts. a lb. for electrolytic copper at the beginning of the year to 12.75 cts. at its end, but failed during the last half of the year to stimulate the expected buying for manufacturers stocks.

Labor troubles, forcing an advance in wages early in the year, with subsequent reductions and strikes, and a general lessening of efficiency, together with increased railroad rates on coal and other supplies, added greatly to the cost of producing the metal.

The world's production for 1920 can only be estimated, but was probably about 949,000 metric tons. That for the year 1919 is not yet definitely ascertainable, as several countries have not yet issued detailed figures. It is estimated at 983,656 metric tons., compared with 1,394,879 tons for 1918. Both these estimates are subject to revision, because neither the Russian nor Austrian production is known. The world's production in 1917 was 1,427,024 tons.

The amount of old copper, brass and alloys, in Europe, largely the salvage of war material, proved much larger than the experts had estimated. One English firm is said to have recovered 300,000,000 lb. from

war material, and continental consumers undoubtedly also hold large amounts; in fact one shipment of 100,000,000 lb. was made from Europe to the United States. This stock of old copper, together with the very adverse rate of exchange, has undeniably had its affect on purchases by foreign consumers. Germany, which has always been our greatest foreign market, was probably a larger purchaser than appears, because her importations were in part indirect, and hampered by our still being technically at war with that country. Our total exports in 1920 amounted to 28.6 per cent. of the refining output, compared with a normal of about 40 per cent.

The United States continued to produce the bulk of the world's copper, the smelter production from domestic ores for 1920 being 1,235,000,000 lb. compared with 1,286,000,000 lb. in 1919, and refinery production from both domestic and foreign sources was 1,573,000,000 lb. compared with 1,768,000,000 lb. in 1919. Official figures show that surplus stocks of refined copper decreased slightly during the year, the figures being 641,474,486 lb. on Jan. 1, 1921, compared with 702,121,233 lb. the year before. Adding the blister copper in transit and metal in course of refining, brings the total of metal on hand to 1,124,000,000 lb. compared with 904,000,000[1] at the end of 1919. This amount is equivalent to the world's production for about six months.

As the American-owned mines in South America, Mexico, and Canada send their smelter output to refineries in this country, the refinery output for the year is larger than the domestic mine production. The Braden and Chile Copper companies actually increased their outputs very materially in 1920.

Japan, holding second place in 1919, was the third-largest copper-producing country in 1920, Chile having outstripped her by about 30,000 tons. It seems probable that when the new plants in process of erection are operating Chile will from that time become firmly established as the world's second-largest copper producer. Mexico, which is a large potential producer of copper, has not yet entirely recovered from its revolutionary troubles, and its production did not equal that of 1918.

The increased costs of production, which have been so marked a feature of mining operations during the past five years, declined but slightly in 1920. The average cost of 16.17 cts. per lb., as determined by the Federal Trade Commission for 1919, was probably the approximate average cost in 1920.

The following article[2] gives a novel and rather striking discussion of the 1920 copper production.

[1] U. S. Geol. Survey figures.

[2] *Min. Sci. Press*, Sept. 14, 1920.

It is generally assumed that the present depression in the copper industry is due to the cessation of European buying since the war and the consequent reduction of output by the producers to an amount much below normal. These mistaken ideas are in large measure dependent on the supposition that the production of copper in the United States has increased at a progressive rate of nearly 10 per cent. per annum, that is, not only has the production of copper increased, but the rate has also increased. The various tables published giving the production and increase by decades seem to confirm the idea, but plotting the figures by years will show that there have been four periods, in each of which the rate of increase in the production was fairly constant. The first, during which the plants took root, lasted until 1881, and developed an annual rate of increase of a little over 3,000,000 lb. per annum; the second commenced with the introduction of electric lighting, lasted until 1895, and had an annual rate of increase of 20,000,000 lb. per annum. The third commenced with the general introduction of electric railways and lasted until the war, with a uniform rate of increase of 40,000,000 lb. per annum. The fourth period was that of the duration of the war and was one of supernormal production, not to be considered as forming any part of the normal periods. It is characterized by excessive expansion unwarranted except by urgent necessity. Adding six times forty millions to the production for 1914 (1,150,137,192 lb.) gives 1,390,000,000 as the hypothetical normal production for 1920. Actually it seems to be at a somewhat higher rate. Thus, even with the great reduction from the war-rate, the production is still in excess of what may be considered normal. Omitting 1913 and 1914, exports had risen to 775,000,000 lb. per annum before the war. The figures for 1913 and 1914 are omitted because they indicate that Germany was already preparing for war by making large importations of copper, her apparent per-capita consumption being 9½ lb. per annum in 1913 as against 7 lb. in the United States. Our exports have already reached the above pre-war quantity, and with the disorganized state of German monetary and industrial conditions it may be safely concluded that further increases will be gradual. In other words, the present rates of production and export are normal or nearly so. James Douglas pointed out, many years ago, the coincidence of the curves showing corresponding conditions in the iron and copper industries, but since the war this agreement has ceased. The production of copper for 1916–'17–'18 was nearly 60 per cent. greater than that for 1912–'13–'14, while the corresponding increase in the pig-iron production was only 38 per cent. Whether this was due to greater foresight or greater difficulty in developing the industry is beside the question, but it fully accounts for the present large surplus in copper and the fact that the price of pig iron is 250 per cent. above pre-war prices, while that of copper is scarcely any higher. In the face of these conditions and the large stocks, which represent fully 8 months export requirements, it must be expected that the improvement in the copper industry will be slow, even though it now seems probable that the next few years will see a new period of expansion marked by increased consumption of copper for the electrification of the railways and similar purposes.

Production

The smelter output of copper in 1920 was 1,209,061,040 lb., a decline of 75,000,000 lb. compared with 1919, or a decrease of 6 per cent. The refinery output as reported by the Copper Export Association was 1,670,759,000 lb. or nearly 36,000,000 lb. more than the figure given by the U. S. Geological Survey, making a decrease of 10 per cent. or 185,000,-

000 lb. compared with 1919, and fully 30 per cent. below the record production of 2,432,385,290 lb. in 1918.

An analysis of the year's figures shows the rather surprising fact that 16 out of the 22 leading copper mining companies of North and South America actually produced more copper in 1920 than in 1919. The largest individual increases were made by the United Verde Extension in Arizona, the Kennecott Copper in Alaska, and the Chile Copper in South America. These three companies produced 75,000,000 lb. more copper in 1920 than in 1919.

The largest individual decrease was that of the Calumet and Hecla properties, in Michigan, producing 101,395,000 lb. or 17,000,000 lb. less than in 1919.

The following table shows the production of each state, as determined by smelter returns:

SMELTERS' PRODUCTION OF COPPER IN THE UNITED STATES[1]
(In Pounds)

State.	1915.	1916.	1917.	1918.	1919.	1920.(a)
Alaska	72,621,844	115,933,315	92,094,023	64,326,616	53,560,128	66,093,924
Arizona	444,089,147	692,630,286	704,156,391	787,338,533	531,777,990	552,988,731
California	37,935,893	51,358,334	46,824,320	43,623,933	21,691,192	11,822,928
Colorado	8,126,000	9,802,183	11,894,900	5,930,200	13,334,000	4,282,616
Idaho	5,602,000	6,741,001	6,401,988	5,051,531	2,737,800	1,922,116
Michigan	241,123,404	270,058,601	274,936,224	236,243,679	163,003,513	153,483,952
Montana	268,027,557	351,995,058	277,362,886	323,377,564	153,903,261	177,743,747
Nevada	66,394,906	100,143,431	115,436,671	115,842,177	63,179,794	55,580,322
New Mexico	75,515,138	83,013,805	110,020,997	92,813,482	54,827,501	52,159,751
Utah	180,951,174	225,396,808	244,443,071	235,978,152	123,124,850	110,357,748
Washington	(a)	(a)	2,152,560	2,290,600	2,667,038	2,125,586
Wyoming	1,020,926	(a)	(a)	(a)	(a)	24,256
East and South	18,858,677	20,018,261	18,704,304	17,292,875	20,072,119	17,349,827
Other States	3,431,494	15,685,226	18,127,568	7,791,545	5,736,027	3,126,436
Total	1,423,698,160	1,942,776,309	1,922,555,903	1,937,900,887	1,209,614,818	1,209,061,040

(a) Included in "Other States." [1] *Eng. Min. Jour.* [2] U. S. Geol. Surv.

SMELTERS' PRODUCTION SINCE 1916—DELIVERIES TO REFINERIES (a)
(In Pounds)

Source.	1916.	1917.	1918.	1919.	1920(b).
North American ore	2,187,328,864	2,161,627,729	2,235,596,681	1,448,228,759	1,209,061,040
Foreign ore	73,391,517	74,410,422	31,128,156	26,788,765	.....
Scrap	37,380,759	41,821,811	41,854,309	28,127,102	.....
Totals	2,298,101,140	2,277,859,962	2,308,579,146	1,503,144,626	.....
To foreign refiners	38,423,577	33,261,435	33,789,554	24,878,520	.....
To American refiners	2,259,677,563	2,244,598,527	2,274,789,592	1,478,266,106	.....
Crude copper imported	152,770,536	274,813,001	256,921,478	(b)263,220,449	244,696,324
Total crude copper	2,412,448,099	2,519,411,528	2,531,711,070	1,741,486,555	.....

(a) *Eng. Min. Jour.* (b) U. S. Geol. Surv.

The crude or casting copper produced by the various smelters of the country is partly marketed as such, but mostly treated in the eleven

electrolytic refineries of the United States, not only to ensure a pure product, but for the extraction of the gold and silver content of the smelter product. The Lake Superior product, or most of it, is sold directly as Lake copper and without refining. There is also a certain amount of direct or primary electrolytic copper, produced directly from this ore by the New Cornelia Co. at Ajo, Ariz., the Mountain Copper Co., and from mill tailings by the Anaconda Copper Co.

The re-smelted, or renovated copper, which is called secondary copper in the governmental reports, is also refined and is an important item of the tables, and in Europe it is this reclaimed copper which in 1920 upset all calculations as to European demand and consumption. As will be noted in the table the "secondary" copper, produced by regular refining plants and imported, in 1920 totaled 81,987,059 lb., this figure including 49,130,510 lb. of casting copper, besides 32,856,549 lb. of electrolytic. This figure will be greatly increased if we add the output of plants, so-called refineries, that treat "secondary" material exclusively. The output of re-smelted copper from these plants amounted to a total of 624,920,000 lb. in 1920, of which 91,000,000 lb. was new copper scrap and 170,200,000 was old copper and alloys other than brass, and 196,000,000 lb. was new brass scrap and 167,720,000 lb. old brass. The total secondary output in 1919 was 724,200,000 lb. This remelted copper in 1920 had a value of $48,060,800, and the remelted brass of $77,454,500.

PRODUCTION OF REFINED COPPER BY REGULAR REFINERIES (*a*)
(In pounds)

	1915.	1916.	1917.	1918.	1919.	1920.
Primary (*b*):						
Domestic—						
Electrolytic	1,114,345,342	1,579,620,513	1,452,744,593	1,560,327,422	1,233,994,324	1,010,240,867
Lake	(*c*) 236,757,062	269,794,531	268,508,091	231,096,158	177,594,135	153,483,952
Casting	21,555,129	12,469,050	69,916,911	15,284,635	18,223,145	13,905,114
Pig and best select	15,047,990	26,868,105	82,376,576	76,165,976	3,674,191	4,793,307
	1,387,705,523	1,888,752,199	1,873,546,171	1,882,874,191	1,433,485,795	1,182,423,240
Foreign (electrolytic)	246,498,925	370,635,116	(*d*)555,000,000	(*d*) 492,181,364	370,558,779	450,194,958
Foreign casting and best select	.....	.....	.....	57,329,735	1,262,227	2,290,446
	1,634,204,448	2,259,387,315	2,428,546,171	2,432,385,290	1,805,306,801	1,634,908,644
Secondary:						
Electrolytic	38,156,789	78,585,296	66,337,771	34,674,062	32,408,548	32,856,549
Casting	21,417,901	25,838,511	12,779,125	9,018,049	38,876,481	49,130,510
	59,574,690	104,423,807	79,116,896	43,692,111	71,285,029	81,987,059
Total output	1,693,779,138	2,363,811,122	2,507,663,067	2,476,077,401	1,876,591,830	1,716,895,703

(*a*) U. S. Geol. Surv.
(*b*) The separation of refined copper into metal of domestic and foreign origin is only approximate, as an accurate separation at this stage of manufacture is not possible. (*c*) Some Lake copper was refined at seaboard plants and doubtless marketed under some brand other than Lake. This has been excluded from the Lake copper. (*d*) Includes refined copper imported.

Summarizing the 1920 production, it appears that improved conditions early in the year were followed by a stagnant market, with prices declining below actual cost of production, forcing a marked curtailment of output. Economic conditions made a complete shut-down unwise, but operators were faced with high costs, low prices, and little demand. These conditions enabled mine managers to dismiss inefficient employees, and to do much needed development work.

It is reported that when one company dismissed half its entire working force the resultant copper output was but one-fifth less than it was before the men were let out.

Consumption

The apparent consumption of new refined copper in the United States during 1920 was 1,053,838,558 lb., compared with 914,471,572 lb. in 1919.

The stock held by refiners on Jan. 1, 1920, was 631,000,000 lb., compared with 180,000,000 lb. a year previous.

CONSUMPTION OF NEW REFINED COPPER IN THE UNITED STATES

Year.	Production.	Stock Jan. 1.	Supply.	Exports.	Stock Dec. 31.	Consumption.
1911	1,431,938,338	122,030,195	1,553,968,533	786,553,208	89,454,695	677,960,630
1912	1,581,920,287	89,454,695	1,671,374,982	775,000,658	105,312,582	791,061,742
1913	1,622,456,829	105,312,582	1,727,769,411	926,441,142	91,348,867	709,979,402
1914(a)	1,533,781,394	90,385,402	1,634,166,796	840,080,922	173,640,501	620,445,373
1915(a)	1,634,204,448	173,640,501	1,807,844,949	681,917,955	82,429,666	1,043,497,328
1916(a)	2,259,387,315	82,429,666	2,341,816,981	784,006,486	128,055,229	1,429,755,266
1917(a)	2,428,546,171	128,055,229	2,556,601,400	1,126,082,417	114,000,000	1,394,829,715
1918(a)	2,432,385,290	114,000,000	2,546,385,290	b)704,715,714	180,000,000	1,661,669,576
1919(a)	1,805,306,801	180,000,000	1,985,306,801	b)439,835,229	631,286,567	914,471,572
1920(a)	1,634,908,644	631,000,000	2,265,908,644	553,070,086	659,000,000	1,053,838,558

(a) U. S. Geol. Surv. (b) Exclusive of manufactured copper.

The surplus, or stock of unsold copper in the hands of the mining companies, smelting companies, etc., has already been mentioned. At the beginning of 1921, the total stock of refined copper was, according to the Government figures, 659,000,000 lb., compared with 631,000,000 the year before, an increase of 28,000,000 lb. If we include stock of blister copper and material in transit, etc., the total was 1,124,000,000 lb. Jan. 1, 1921, compared with 904,000,000 the year previous.

One of the newly discovered uses of copper is the fact that its addition in small quantity, 0.2 to 0.3 per cent., to steel, greatly increases its durability and resistance to corrosion. This makes copper particularly valuable for wire fencing, for railroad ties, plates, and sheets. An official report by the American Society for Testing Materials shows that the life of sheet metal is doubled.

Exports

Exports of copper in 1920 were large compared with pre-war purchases, if one makes a reasonable allowance for Germany's abnormal

buying for two years before the war, and the exports for 1920 were 20 per cent. more than those of 1919.

During the year 1920 the United States exported 624,053,701 lb. of copper, mainly as ingots, bars, rods, pipes, plates, sheets and wire, but also inclusive of a small amount of ore, concentrate, composition metal and scrap. This figure compares with 516,627,775 lb. in 1919.

In addition to the above amount, considerable copper is exported in the brass sent abroad, amounting to 9,030,288 lb. in 1920, valued at $15,128,651, compared with 10,208,346 lb. valued at $13,912,878 in 1919. This copper is, however, included in domestic consumption, as it is made into brass articles, etc., before export.

The following table, which presents a summary of copper exports for the past six years, does not convey a correct impression of peace-time trade, especially with the Teutonic nations, which normally are extensive users of copper for electrical appliances and machinery of every kind.

EXPORTS OF COPPER FROM THE UNITED STATES
(In pounds)

Country.	1915.	1916.	1917.	1918.	1919.	1920.
Ore and matte (a)...	129,317,440	5,784,768	5,957,295	3,259,839	668,667	440,906
Refined ingots, bars, etc.						
Exported to:						
United Kingdom...	201,218,655	173,003,875	372,743,338	251,805,814	105,619,710	99,479,801
Belgium...	.....	.....	.....	.....	.....	28,090,450
France...	236,236,135	318,136,643	366,231,608	265,270,793	89,188,652	118,489,043
Germany...	.....	.....	.....	.....	6,831,400	89,194,588
Italy...	107,101,156	98,249,149	152,997,819	121,907,864	65,343,538	918,802
Netherlands...	4,018,841	.....	.....	.....	.....	34,228,046
Russia...	37,430,402	56,777,486	75,037,925	.....	.....	.....
Japan...	.....	.....	.....	33,075	65,595,603	82,913,730
Other Europe...	56,013,517	.....	.....	.....	.....	43,420,732
Canada...	24,127,098	41,900,063	49,867,577	33,087,082	19,781,227	29,697,098
Other countries...	15,771,151	28,549,547	13,901,061	17,923,325	85,800,688	24,794,503
Total refined...	681,917,955	716,616,763	1,030,779,328	690,027,953	438,160,818	551,226,793
Blister and black...	(b)	18,263,118	16,992,357	14,687,823	1,674,411	1,843,293
Alloys...	(b)	(c)	(c) 1,228,032	186,260	364,089	454,306
Old and scrap...	(b)	815,825	1,070,389	257,403	449,084	577,319
Pipes and tubes...	(b)	(c)	(c) 7,260,833	4,109,226	5,993,959	4,899,223
Plates and sheets...	(b)	24,843,435	42,664,943	19,471,584	13,764,425	22,799,148
Wire, not insulated...	(b)	23,467,345	26,879,498	15,689,554	55,551,602	41,812,713
Grand total...	.....	789,791,254	1,132,832,663	747,689,642	516,627,775	624,053,701

(a) Until 1916 the exports of ore and matte are reported as gross weight, the copper contents not being stated. (b) Included in "Refined ingots, bars, etc." (c) Not separately listed until July 1, 1917.

It is an interesting fact that during the first 10 months of 1920 France took more copper from the United States than Great Britain did, the shipments being 47,986 tons and 45,434 tons respectively. During this same period 27,169 tons went to Germany and 2039 tons to Holland, while Belgium took nearly 3000 tons. Japan continued to absorb copper, receiving 43,000 tons during the year.[1]

[1] *Metal Bull.*, Feb. 8, 1921.

IMPORTS

The United States receives large amounts of copper ore and crude copper sent here to be smelted or refined. Most of this comes of course from American-owned mines in Chile, Cuba, Peru, Mexico and Canada. These imports of copper in unmanufactured form totaled 488,039,067 lb. in 1920, compared with 429,387,594 in 1919, and 575,805,115 in 1918. The copper in matte of foreign origin amounted to 17,594,174 lb., compared with 40,325,472 in 1919.

Copper concentrates imported in 1920 contained 46,797,590 lb. of copper against 36,413,080 in 1919, and ore 52,045,291 lb. compared with 49,716,511 lb. in 1919. Unrefined blister-copper bars, pigs, etc., constituted as usual the bulk of the imports, totaling 244,696,324 lb. in 1920, and 263,220,449 in 1919.

The imports of refined copper, mainly from Chile, reached the surprising total of 120,161,609 lb. in 1920, contrasted with only 35,138,760 lb. in 1919. There was a similar increase in old copper and clippings from 4,217,340 lb. in 1919 to 11,558,367 lb. in 1920, and of copper in composition metal of various kinds from only 355,982 lb. in 1919 to 4,235,647 lb. in 1920.

The imports for six years past are summarized in the table below.

IMPORTS OF COPPER INTO THE UNITED STATES (a)
(In pounds)

Country.	1915.	1916.	1917.	1918.	1919.	1920.
Ore and matte. Imported from:						
Germany	.....	.....	.....	.....	.....	.....
Spain	1,278,403	2,659,211	371,902	.....	2,157,072	2,123,594
Cuba	28,876,226	40,644,140	45,343,462	28,716,903	15,979,585	18,446,649
Canada	29,591,823	37,344,754	31,134,172	31,718,784	28,201,213	28,556,362
Mexico	14,707,724	33,525,559	40,168,291	64,879,683	57,370,307	34,176,192
Chile	33,435,039	44,508,322	43,906,869	18,947,088	15,500,966	18,510,907
Other countries	6,442,226	16,105,868	14,822,411	12,954,023	7,245,920	5,573,916
Total	114,331,441	174,787,854	175,747,107	157,216,481	126,455,063	107,387,620
Blister and black. Imported from:						
United Kingdom	7,485,625	1,554,649	.....	112,738	228,083	5,939,811
Spain	7,964,534	550,290	.....	165,011	.....	.....
Canada	44,977,829	47,951,823	40,571,204	37,881,986	31,199,467	26,287,350
Mexico	15,973,838	61,756,926	40,213,831	83,568,187	52,609,210	72,670,790
Chile	36,303,505	70,762,349	162,227,104	156,285,580	89,859,898	46,289,793
Peru	61,342,067	72,827,909	100,302,275	81,492,209	80,829,505	82,509,806
Australia and Tasmania	443,520	.....	.....	.....	.....	.....
Japan	17,970,768	9,192,010	6,393,524	827,404	600	.....
Other countries	8,905,322	4,331,359	5,890,018	18,038,556	8,493,686	7,794,392
Total (b)	201,367,008	268,927,315	355,598,036	378,371,651	263,220,449	244,696,324
Refined ingots, bar, etc.	(c)	8,411,230	6,751,958	38,087,769	35,138,760	120,161,109(c)
Scrap and old	(c)	9,451,388	17,893,594	1,921,539	4,217,340	11,558,367
Alloys	(c)	758,193	429,702	207,675	355,982	4,235,647

(a) The imports reported are the copper contents of ore, matte, and regulus. (b) Includes also refined, scrap, etc., until 1916. (c) Included in "Blister and black." (c) 101,000,138 lb. from Chile.

World's Production

The world's aggregate production of the red metal was slightly less in 1920 than it was in 1919, being estimated at 949,015 metric tons compared with 983,656 in 1919, and with 1,394,879 in 1918, and about equal to that of 1913 and 1914. This was the result largely of American conditions, but Russia has not been credited with any production for

THE WORLD'S COPPER PRODUCTION
(In metric tons)

Country.	1913.	1914.	1915.	1916.	1917.	1918.	1919(g).	1920(g).
Africa (a) { Cape Co....	5,812	3,125	} d27,327	(d)34,572	45,138	31,110	31,350	32,230
Africa (a) { Namaqua...	2,540	2,328						
Africa (a) { Other.....	17,059	18,682						
Argentina (a).....	117	.....	.....	.....	.....	.....	.....	.....
Australasia (a).....	47,326	37,590	32,512	(d)35,000	(d)38,100	33,838	16,441	26,486
Austria-Hungary (a)..	4,135	3,310	.....	.....	.....	.....	1,000	1,000
Bolivia (a).....	3,658	2,743	*3,000	*4,000	*4,000	*4,000	7,000	9,900
Canada (d).....	34,587	34,027	47,202	47,985	50,626	52,693	36,106	35,500
Chile (d).....	40,195	40,876	(f)52,081	(f)71,430	83,100	85,850	63,930	94,531
Cuba (d).....	3,517	6,251	8,836	7,816	10,313	12,337	9,974	6,485
Germany (a).....	25,309	30,480	25,539	24,796	28,632	15,101	15,775	17,255
Italy (a).....	1,626	2,410	(f)1,840	(f)1,867	(f)1,248	(f)1,114	(f)1,243	.....
Japan (f).....	(a)73,152	68,058	75,415	81,280	111,256	95,800	81,865	65,554
Mexico (d).....	52,815	36,337	30,969	55,128	47,503	75,529	60,491	50,480
Norway (a).....	11,796	2,860	2,867	1,162	1,810	2,856	1,800	1,400
Peru (e).....	(d)25,715	23,647	(d)32,410	(f)41,625	45,260	44,800	39,470	31,276
Russia (c).....	42,970	31,938	(d)25,881	(d)20,877	*16,000	*5,000	.....	.....
Spain-Portugal (a)....	54,696	37,099	*46,200	*42,000	*42,000	*41,000	40,000	25,000
Rio Tinto (a).....	36,901	21,515	.....	.....	.....	.....	.....	.....
Tharsis (a).....	3,270	.....	.....	.....	.....	.....	.....	.....
Mason & Barry (a).	3,185	.....	.....	.....	.....	.....	.....	.....
Sevilla (a).....	1,535	.....	.....	.....	.....	.....	.....	.....
Sweden (c).....	6,891	4,692	4,561	3,181	4,423	2,956	3,558	3,500
Turkey (a).....	508	.....	.....	.....	.....	.....	.....	.....
United Kingdom (f)..	305	347	238	282	190	203	(c)146	.....
United States (d).....	557,387	525,529	646,212	881,237	872,065	865,692	(b)583,507	(b)548,418
Total.....	1,002,284	934,888	1,063,090	1,363,238	(i)1,427,024	(i)1,394,879	983,656	949,015

(a) As reported by Henry R. Merton & Co., Ltd., of London until 1914. (b) U. S. Geol. Surv. (c) As officially reported. (d) As reported by the *Eng. Min. Jour.* (f) As officially reported. (g) Am. Bureau of Metal Statistics, except as noted. (h) Henry R. Merton & Co., through *Eng. Min. Jour.* (i) Includes 25,000 tons estimated production of other countries.
*Estimated.

WORLD'S PRODUCTION OF COPPER (a)

Year.	Metric Tons.	Short Tons.	Year.	Metric Tons.	Short Tons.	Year.	Metric Tons.	Short Tons.
1885....	229,315	252,828	1897...	412,818	455,147	1909...	854,758	942,408
1886....	220,669	243,295	1898...	441,282	486,529	1910...	877,494	966,998
1887....	226,492	249,716	1899...	476,194	525,021	1911...	879,751	969,750
1888....	262,285	281,179	1900...	491,435	541,561	1912...	1,011,312	1,114,769
1889....	265,516	292,741	1901...	529,508	583,517	1913...	1,002,284	1,104,517
1890....	274,065	302,166	1902...	542,606	597,951	1914...	934,888	1,018,395
1891....	280,138	308,862	1903...	630,590	694,910	1915...	1,094,803	1,206,793
1892....	309,113	340,808	1904...	693,240	764,758	1916...	1,408,280	1,552,347
1893....	310,704	342,562	1905...	698,931	770,221	1917...	1,435,721	1,582,595
1894....	330,075	363,920	1906...	715,510	788,492	1918...	1,395,160	1,537,884
1895....	339,994	374,856	1907...	724,120	798,205	1919...	983,656	1,084,284
1896....	384,493	423,917	1908...	758,065	835,623	1920...	949,015	1,044,299

(a) The statistics for 1885–1891 are as reported by Henry R. Merton & Co.; 1892–1918 as per Mineral Industry.

several years past, though in former years the mines of that country, including Siberia, produced from 20,000 to 33,000 tons.

PRICES

The price of copper at the beginning of 1920 averaged 19 cts. and at the close of the year 12.5 or 12.75 cts., producers' price. The average for the year was 18.433 cts. a lb. for 1,724,000,000 sold.[1] The monthly average[2] for electrolytic was 18.918 cts. in January, falling very gradually to 18.144 in September. A sharp break by the producers lowered the average to 15.934 in October, 14.257 in November and 13.188 in December.

AVERAGE PRICE OF ELECTROLYTIC COPPER PER POUND IN NEW YORK (a)
(In cents per pound)

Year	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1908.	13.726	12.905	12.704	12.743	12.598	12.675	12.702	13.462	13.388	13.354	14.130	14.111	13.208
1909.	13.893	12.949	12.387	12.563	12.893	13.214	12.880	13.007	12.870	12.700	13.125	13.298	12.982
1910.	13.620	13.332	13.255	12.733	12.550	12.404	12.215	12.490	12.379	12.553	12.742	12.581	12.738
1911.	12.295	12.256	12.139	12.019	11.989	12.385	12.463	13.405	12.201	12.189	12.616	13.552	12.376
1912.	14.094	14.084	14.698	15.741	16.031	17.234	17.190	17.498	17.508	17.314	17.326	17.376	16.341
1913.	16.488	14.971	14.713	15.291	15.436	14.672	14.192	15.400	16.328	16.337	15.182	14.224	15.269
1914.	14.223	14.491	14.131	14.211	13.996	13.603	13.223	(b)	(b)	(b)	11.739	12.801	13.602
1915.	13.641	14.394	14.787	16.818	18.506	19.477	18.796	16.941	17.502	17.686	18.627	20.132	17.275
1916.	24.008	26.440	26.310	27.895	28.625	26.601	23.865	26.120	26.855	27.193	30.625	31.890	27.202
1917.	28.673	31.750	31.481	27.935	28.788	29.962	26.620	25.380	25.073	23.500	23.500	23.500	27.180
1918.	23.500	23.500	23.500	23.500	23.500	23.500	25.904	26.000	26.000	26.000	26.000	(c)	24.628
1919.	(c)	16.763	14.856	15.246	15.864	17.610	21.604	22.319	21.755	21.534	19.758	18.295	18.691
1920.	18.918	18.569	18.331	18.660	18.484	18.065	18.576	18.346	16.144	15.934	14.257	13.188	17.456

(a) From *Eng. Min. Jour.* (b) No quotation. (c) No market.

AVERAGE MONTHLY PRICES OF COPPER MANUFACTURES (a)
(In cents per pound)

	1918.		1919.		1920.	
	Wire.	Sheet.	Wire.	Sheet.	Wire.	Sheet.
Jan.	26.50	31.50	22.63	29.00	22.81	29.31
Feb.	26.56	31.50	20.19	26.41	23.00	29.50
Mar.	26.43	31.50	17.76	22.78	23.00	29.50
Apr.	26.50	31.50	17.16	22.50	23.00	29.50
May.	26.62	31.50	18.00	23.26	23.00	29.50
June.	26.64	31.90	20.35	25.34	23.00	29.50
July.	29.50	34.25	25.38	31.22	23.00	29.50
Aug.	29.50	34.50	26.46	33.50	23.00	29.50
Sept.	29.50	35.00	26.19	33.50	23.00	29.50
Oct.	29.75	35.25	25.38	33.11	22.65	27.63
Nov.	29.00	35.60	23.63	31.33	20.08	23.73
Dec.	27.70	35.65	21.96	28.50	17.00	22.50
Year.	27.85	33.30	22.09	28.37	22.21	28.26

(a) *Eng. Min. Jour.*

[1] U. S. Geol. Surv. figures.
[2] *Eng. Min. Jour.* figures

AVERAGE PRICE OF STANDARD COPPER (G. M. B.'S) IN LONDON (a)
(In pounds sterling per ton of 2240 lb.)

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1909.....	61.198	57.688	56.231	57.363	59.338	59.627	58.556	59.393	59.021	57.551	58.917	59.906	58.732
1910.....	60.923	59.388	59.214	57.238	56.313	55.310	54.194	55.733	55.207	56.722	57.634	56.069	57.054
1911.....	55.604	54.970	54.704	54.035	54.313	56.368	56.670	56.264	55.253	55.176	57.253	62.063	55.973
1912.....	62.760	62.893	65.884	70.294	72.352	78.259	76.636	78.670	78.762	76.389	76.890	75.516	72.942
1913.....	71.741	65.519	65.329	68.111	68.807	67.140	64.166	69.200	73.125	73.383	68.275	65.223	68.355
1914.....	64.304	65.259	64.276	64.747	63.182	61.336	60.540	(b)	(b)	(b)	53.227	56.841	61.524
1915.....	60.756	63.494	66.152	75.096	77.600	82.574	76.011	68.673	68.915	72.601	77.744	80.773	72.532
1916.....	88.083	102.667	107.714	124.319	135.457	112.432	95.119	110.283	113.905	122.750	134.659	145.316	116.029
1917.....	131.921	137.895	136.750	133.842	130.000	130.000	128.409	122.391	117.500	110.000	110.000	110.000	124.892
1918.....	110.000	110.000	110.000	110.000	110.000	110.000	119.913	122.000	122.000	122.000	122.000	118.447	115.530
1919.....	92.238	78.700	76.821	77.300	77.767	83.062	99.576	97.300	100.767	103.418	98.894	103.708	90.796
1920.....	118.095	120.188	109.533	103.025	96.750	87.864	90.148	93.935	96.381	93.327	84.807	75.702	97.480

(a) From *Eng. Min. Jour.* (b) No quotation.

Costs

The cost of producing copper varies widely at different mines, but the same general factors affect costs of all producers. The average costs were 16.123 cts. per lb. in 1918, which compares with an average selling price of 16.75 cts. for the 10 years preceding the World War. Despite higher railroad rates and coal costs with but slight reduction on mine supplies and labor, costs declined a little, especially for the "porphyry" coppers, the average of four leading producers being 15.1 cts. per lb. of copper for the first half of 1920. In 1916, the Utah Copper Co. produced its copper for 6.95 cts. per lb. In the latter part of 1920, the cost was 17.3 cts. per lb., or if we deduct the precious-metal values, 15.16 cts. The average for all the United States mines for 1920 is 15.5 cts., compared with 10.5 cts. for 1913. It must be remembered, however, that all costs for years preceding 1916 were figured without depletion, depreciation and other items, which are vitally important when the income taxes are calculated.

THE MINERAL INDUSTRY for 1919 gives a detailed discussion of costs with the data gathered by the War Industries Board, and should be consulted by those interested in this phase of the subject. Grouping the mines in classes, these tables show that in 1918 the 21 mines of the Lake Superior district produced 10 per cent. of the country's production at a weighted average cost of 17.622 cts. per lb.; the 11 porphyry coppers, 34.47 per cent. at an average cost of 14.886 cts., and 53 other mines produced 55.52 per cent. at a cost of 16.7 cts. per lb.

Copper Mining in the United States

The year 1920 was not a prosperous one for the copper mines of the United States, though most of the large mines continued in operation.

The five great copper camps of Arizona, Jerome, Ray, Globe, Miami, Bisbee, and Ajo maintained that State's supremacy as a copper producer.

The Anaconda, at Butte,Mont., was the world's largest individual producer, and the Utah Copper Co. at Bingham, Utah, mined the largest tonnage of ore and was the second-largest metal producer. The "Porphyry Coppers," mining deposits of low-grade disseminated ore, continue to dominate the American industry, furnishing about 35 per cent. of the United States production, at a lower average cost per pound, on a less initial investment, than any other group. The United Verde Extension continued to be the lowest-cost producer.

Alaska.—The eight copper mines which were in operation in 1919 continued mining during 1920. The total production was 76,435,363 lb. of copper as against 44,800,000 lb. for 1919.

The Kennecott Copper Corporation was as usual responsible for much the larger part of the output, derived from its three mines in the Chitina district and from the Beatson-Bonanza property on Latouche Island. The smelter receipts were 51,365,261 lb. Other production on Prince William Sound is reported from the Schlosser mine of the Alaska Mines Corporation and the McIntosh owned by the Fidalgo Mining Co., but only of small amount. The Ladysmith Smelting Corporation did much development work on the Girdwood mine, but no shipments were reported.

In the Ketchikan district, in southeastern Alaska, the Rush & Brown mine was the only producing copper mine in 1920, although the Platinum Palladium Producing Corporation operating the Salt Chuck mine produced some 400,000 lb. of copper as a by-product. The reputation of this mine rests on the occurrence of palladium and platinum in its ores.

There were apparently no important discoveries of copper deposits during 1920, either in known fields or in new districts.

Arizona.—Continuously since 1910 Arizona has been the banner state as a copper producer, and in 1920 with a total of 558,256,302 lb. exceeded Montana, its nearest competitor, by more that 375,000,000 lb. The production for 1919 was 538,100,844 lb. and the respective values for 1919 and 1920 were $98,296,000 and $95,341,000. Gila County, which includes the Globe and Miami districts, was first on the county list, followed by Cochise, which takes in the Copper Queen mine, and Yavapai County, in which are situated the United Verde and the adjoining United Verde Extension properties.

Gila County.—The Miami Copper Co., operating at 75-per cent. capacity, produced 55,581,328 lb. of copper in 1920, and in doing this reduced both the cost of mining and milling, with the result that the cost per pound of copper was about 1 ct. less than in 1919. Ore reserves of the so-called high-grade sulphides were increased and at the end of the year totaled 10,723,410 tons at 2.26 per cent. copper. Its neighbor, the

Inspiration Consolidated Copper Co., reports a production of 79,453,740 lb. of copper at a cost of 14.17 cts.

The Superior & Boston Copper Co. for the 12 months ending September, 1920, produced 1,062,379 lb. The Old Dominion Co., including copper contained in custom ores, produced 22,818,025 lb. for the year 1920.

The production figures of the Arizona Commercial Mining Co. and the Iron Cap Copper Co. were 7,913,836 and 8,235,670 lb. of copper, respectively. The latter began the operation of its newly constructed mill in June.

Cochise County.—The Copper Queen branch of the Phelps Dodge Corporation, at Bisbee, was the only branch of this company in Arizona to show production on a large scale. Work at the Morenci and Bunker Hill branches was practically confined to development and exploratory work. The 1920 output of the Copper Queen was 71,443,396 lb. of copper from 832,172 tons of ore of all kinds. The larger part of the ore was treated at the mine reduction works, but 233,914 tons of low-grade ore was sent to the leaching dump. The Copper Queen smelter altogether reduced 787,985 tons, which included ores from the other branches.

From its mines in the Warren district, the Calumet & Arizona Mining Co., operating at less than 60 per cent. of normal capacity, reports a copper production of 43,440,744 lb., something like 11 per cent. less than in 1919. Operations were curtailed in every department, and towards the end of 1920 all mining activities were confined to the Junction shaft. Of the mine output, 493,672 tons of ore was shipped to the smelter at Douglas, of which 398,648 tons was smelted. The smelter, however, treated 193,266 tons of custom ores additional, and produced altogether 26,644,409 tons of blister, or at the rate of about 47 per cent. of actual capacity. The acid plant produced 39,996 tons of 60° acid, much the larger part of which was shipped to the sister company, the New Cornelia Copper Co., described elsewhere. Mention is made of the Eighty-five branch of the Calumet & Arizona under *New Mexico.*

Because of unsettled labor conditions operations of the Shattuck Arizona Co. were far from satisfactory and all work was discontinued in October, 1920. Up to that time, the copper production amounted to 2,374,148 lb. The company's explorations at the Con Virginia ceased at the end of the year and the property reverted to the owners.

Yavapai County.—At Jerome, the huge mining enterprise of the United Verde Copper Co. produced 64,952,270 lb. of copper and sold during the year 50,822,335 lb. at an average price of 18.31 cts., and with a

total value of $9,305,739. Dividends amounting to $6 per share were distributed.

The much more recently organized United Verde Extension Mining Co., operating adjoining properties, reports for 1920 a production of 41,942,700 lb. of copper from 161,617 tons of ore smelted. There was actually mined 164,307 tons of ore averaging 12.84 per cent. copper with some gold and over 2 oz. of silver per ton. Estimates of ore reserves show a total above the 1500-ft. level of 1,148,800 tons with a copper content of 11.81 per cent.

Other Counties.—In Pinal County, the mine of outstanding importance is that of the Ray Consolidated Copper Co. This company produced from ore and concentrates 47,062,030 lb. of copper in 1920 as compared with 46,011,371 lb. in 1919. The 1920 cost of production was 16.14 cts. per lb. The mill treated 1,706,928 tons of ore with a copper extraction of 81.98 per cent. Total ore reserves on Dec. 31 were 83,004,043 tons averaging 2.068 per cent. copper.

The New Cornelia Copper Co., operating at Ajo, Pima County, is closely allied to the Calumet & Arizona. Its production for 1920 was 40,104,493 lb. of copper as against 39,509,461 lb. in 1919. Dividends amounting to $900,000 were paid during the year.

California.—The copper production of this State for 1920 was 11,822,028 lb., or about one-half of that reported for 1919. In the latter year the total was 22,299,656 lb., valued at $4,236,934.

Plumas County supplied the greater part of the production, yielding something like 9,000,000 lb., with Calaveras County in second place, showing an output of about 2,000,000 lb. In the former county the Engels Copper Mining Co. is probably the most productive copper mining enterprise in California. This company produced 8,571,000 lb. of copper from its Superior and Engels mines during 1920, and increased the capacity of its flotation plant to 1500 tons of ore per day. The ore reserves are reported to be sufficient to supply the mill for 10 years with ore carrying a copper content of from 2.25 to 2.50 per cent.

The Walker Mining Co., a subsidiary of the Anaconda Copper Mining Co., shipped 2295 tons of concentrate from its 200-ton mill, which yielded 907,988 lb. of copper; actually 7399 tons of concentrate was produced. This company completed during 1920 an 8-mile aerial tramway from the mill to the railroad. Except for development work, operations were suspended in November.

The Iron Mountain mine, of the Mountain Copper Co., Ltd., at one time one of the world's largest copper producers, was practically idle in 1920; the company, however, made shipments of pyrite ores from its Hornet mine. At Ingot in Shasta County the Afterthought Copper Co.

suspended operations after a few months. This company is equipped with a flotation plant and smelter, but has had much difficulty in the treatment of its complex zinciferous ores.

A new organization, the Shasta Zinc & Copper Co., has taken over the Bully Hill mine and smelter, and is building a 150-ton zinc plant for the manufacture of oxide. The Bully Hill ore carries chalcopyrite with zinc, antimony, and a little gold and silver. The Calaveras Copper Co. also operated both concentrator and smelter, and remained active until October, mining 300 tons of 2-per cent. copper ore per day.

The Mammoth mine and smelter in Shasta County, which were closed down in 1919, remained idle throughout 1920, except for exploratory work. Both this mine and the Keystone have reserves of 4 to 6-per cent. copper smelting ore and large bodies of pyrite with a small copper content. The Balaklala Consolidated also was idle in 1920, as in 1919.

In Siskiyou County, the Mason Valley Mines Co., of Nevada, continued the development of its Gray Eagle mine, and by numerous tunnels has blocked out 1,045,000 tons of 3.23-per cent. copper ore and 50,000 tons of a 1-per cent. grade.

Colorado.—This State had an average annual copper production for five years prior to 1918 of a little over 8,000,000 lb., but in 1919 the output fell to 4,892,588 lb. and the reports for 1920 show a further decrease to 4,282,616 lb.

Much of the copper produced in Colorado is in the nature of a by-product derived from gold-silver and lead ores. Perhaps less than 30 per cent. can be credited to ores of which copper is the prime metal.

Idaho.—With the possible exception of California, this State shows the greatest falling-off in its production of copper, 1,922,116 lb. in 1920 as against 3,140,000 lb. in 1919, a rate of decrease greater even than that recorded between the years 1918 and 1919. The value of the 1919 product was about $591,000 and that of 1920 $330,000. Labor shortage and the slump in metal prices made 1920 a difficult year for the mines.

Of the counties, Custer was far ahead, followed by Lemhi and Shoshone. Although with a smaller output than in previous years, the Empire Copper Co. was the largest individual producer of copper. The Harmony Mines Co., operating in Lemhi County, recovered 93,740 lb. of copper in concentrates; as the extraction was only about 55 per cent., the installation of a flotation unit is being urged. The mines of the National Copper Mining Co., Ltd., near Mullan, and of the Richmond Mining and Milling Co., near Adair, were idle in 1920.

In the Snake River Canyon, in Adams County, the Idaho Copper Co., Ltd., is continuing its exploratory work at the Red Ledge mine. Accord-

ing to Robert N. Bell, former State Mine Inspector of Idaho, there are already indications of a 10,000,000-ton reserve of ore with a 2.85-per cent. copper content, with $4.20 in gold and silver per ton.

Michigan.—The Lake Superior district produced 153,483,952 lb. of copper in 1920, about on a par with the production of the first pre-war year. In 1919, the total figure was 201,716,335 lb. Most, if not all, of the companies incurred financial losses, and such dividends as were paid were distributed from surplus. Operations throughout the field were purposely curtailed throughout the year, and increasingly so as the price of copper decreased.

Through its large stock ownership in the Atlantic and Trimountain mining companies, its one-half ownership of the holdings of the Champion Copper Co., and complete ownership of the Baltic mine, the Copper Range Co. has commonly been the second-largest copper producer in Michigan. Of the subsidiary companies, the Atlantic has been inactive for a number of years.

The Copper Range has done little more since the fall of 1918 than to keep its working organization intact, which accounts for its decreased production, which in 1920 was 16,951,105 lb. of copper produced at a cost of 17.77 cts., compared with 23,082,498 lb. costing 15.02 cts. per pound in 1919. The company ended the year with an operating deficit of $4839.

The Calumet & Hecla Mining Co., operating on the Conglomerate and Osceola lodes, produced in 1920 a total of 43,489,643 lb. of copper from 1,560,240 tons of rock at a cost of 20.73 cts. per pound of copper. In this same period, 43,019,141 lb. of copper was sold at a price per lb. of 18.76 cts. The company's statement shows a net operating loss of $3,823,743 for 1920, and only $500,000 paid in dividends.

Perhaps the one striking feature to this company's activities during 1920 was the substantial increase in the material handled by its reclamation plant. This department was initiated in 1913, and put in operation two years later, to treat the sands from Torch lake, and has recovered 48,537,488 lb. of copper from 4,467,168 tons of sand in 6 years, at a cost of 6.47 cts. per pound of copper. In 1920, 1,378,500 tons of sand yielded 14,138,240 lb. of copper at a cost of 6.60 cts., a production 50 per cent. in excess of any previous year.

The group of companies of which the Calumet & Hecla has control made a combined production of 43,870,906 lb. of copper. Individually, they may be listed as follows: Ahmeek Mining Co. produced 20,489,438 lb. of copper from 822,192 tons of rock at a cost of 16.08 cts. per lb.; Allouez Mining Co. reports a production of 2,499,239 lb. of copper, over a million pounds less than in 1919, costing 23.90 cts. per lb.; the

Centennial Copper Mining Co. produced 561,284 lb. only, a marked reduction from the figure of 1919, at a cost of 36.17 cts. per lb.; Isle Royale Copper Co. reports 10,621,801 lb. of copper produced from 591,971 tons of rock at a cost of 20.10 cts. per lb.; the production of the La Salle Copper Co. was about one-sixth of that for 1919, or 59,713 lb. of copper only; the Osceola Consolidated Mining fell more than 3,000,000 lb. behind the 1919 figure with a production of 7,465,773 lb. of copper, costing 24.18 cts. per lb.; the Superior Copper Co. had a production of only 322,871 lb. of copper at the maximum cost figure of 44.65 cts. per lb.; and the White Pine Copper Co. produced 1,850,787 lb. of copper from a rock tonnage of 93,260 at a cost of 28.91 cts. per lb. of copper.

COPPER PRODUCTION IN MICHIGAN
(Pounds of fine copper)

Mines.	1912.	1913.	1914.	1915.	1916.	1917.	1918.	1919.	1920.
Adventure..	8,727,312	.....	.....	.....	*Nil*	*Nil*	*Nil*	*Nil*	*Nil*
Ahmeek....	16,455,769	9,220,874	13,643,605	21,800,492	24,142,158	27,919,812	24,851,235	17,223,111	20,489,438
Allouez....	5,525,455	4,091,129	6,056,548	10,043,459	10,219,290	8,892,915	7,071,218	3,749,984	2,499,239
Atlantic....	*Nil*	44,370	.....	.....	(*b*)	(*b*)	(*b*)	(*b*)	(*b*)
Baltic.....	13,373,961	7,736,124	7,001,945	12,028,947	(*b*)	(*b*)	(*b*)	(*b*)	(*b*)
Cal. & Hecla.	67,856,429	45,016,890	53,691,562	72,613,320	76,762,240	77,495,283	67,968,357	52,859,146	43,489,643
Centennial..	1,742,338	1,612,262	2,287,532	2,347,509	2,367,400	2,002,857	2,492,857	1,365,148	561,284
Champion..	17,225,508	12,080,592	15,807,206	33,407,599	54,747,498	31,268,130	21,748,514	23,082,498	16,951,105
Franklin ...	1,710,651	1,021,440	93,283	1,314,969	3,116,566	3,155,577	2,827,313	1,062,879	*Nil*
Isle Royale.	8,186,957	4,158,584	6,593,451	9,342,106	12,412,111	13,480,921	15,442,508	13,007,647	10,621,801
Mass.....	2,045,006	1,213,545	2,944,952	4,638,452	4,752,588	4,000,000	3,403,827	1,963,178	*Nil*
Michigan...	300,000	.....	.....	.....	.....	.....	1,177,176	1,697,107	1,075,442
Mohawk....	11,995,598	5,778,235	11,094,859	15,882,914	13,834,034	12,313,887	.....	12,850,000	10,269,824
Osceola.....	18,413,387	11,325,010	14,970,737	19,731,472	19,586,501	16,084,958	15,919,647	.....	7,465,773
La Salle....	.....	287,200	540,731	*a* 700,000	1,380,352	1,919,775	.....	340,719	59,713
Quincy.....	20,634,800	12,184,128	15,356,380	22,045,813	21,065,612	22,195,577	19,948,965	.....	19,216,070
Superior....	3,921,974	2,992,765	3,217,635	4,000,000	3,034,656	2,201,672	1,676,446	563,935	322,871
Tamarack..	7,908,746	4,168,743	1,074,808	3,888,150	6,606,620	.....	.....	.....	*Nil*
Trimountain	6,980,713	4,990,938	5,048,306	8,302,896	(*b*)	(*b*)	(*b*)	(*b*)	(*b*)
White Pine.	.....	.....	.....	.....	4,207,449	4,067,529	3,273,680	1,979,268	1,850,787
Winona....	2,307,237	1,448,737	1,352,084	1,732,638	2,167,255	1,494,472	19,400,000	561,238	(*c*)
Wolverine..	9,408,960	8,350,312	3,435,459	7,250,866	6,541,492	5,856,889	4,608,865	4,562,617	3,299,086
Victoria....	1,224,911	4,488,000	1,486,242	1,499,695	1,661,832	1,612,640	1,533,536	1,245,590	1,060,829
Totals ...	225,945,712	135,409,566	165,697,325	253,710,422	273,692,525	268,508,091	231,096,158	201,716,335	153,483,952

(*b*) Included in Champion (Copper Range Co.). (*c*) A small production.

Operations at the mill of the Lake Milling, Smelting & Refining Co., in which the Allouez and other subsidiaries have a controlling interest, were suspended in 1920, and thus the ores of the Allouez, Centennial, and a part of those from the Isle Royale were treated at the Osceola mill. The plant of the Lake Superior Smelting Co., closed down in May, 1919, continued inactive throughout 1920.

As evidencing the reduced and unprofitable activities of the subsidiaries, it may be noted that dividends accruing to the Calumet & Hecla amounted to $182,312, all from the Ahmeek and Osceola, compared with $472,371 in 1919.

After making a production of a few hundred thousand pounds of copper early in 1920, the Winona Copper Co. suspended operations in

May. The Wolverine Copper Co. produced 3,299,086 lb. of copper in 1920; one-third of the rock output was obtained from the foot-wall in the older workings. Shaft-pillars in the lowest levels are now being exploited, but the mine without increase of territory is reported to have a life of between 8 and 10 years.

One interesting news item from the Lake Superior district is the increased hoisting equipment at the No. 2 shaft of the Quincy Mining Co. The new hoist is said to be the largest yet constructed. This company has added also a new furnace capable of refining 130,000 lb. of copper in one charge. The 1920 production of the Quincy was 19,216,070 lb. of copper, as against 19,476,320 lb. in 1919. The statement of operations reports a deficit of $530,741 for 1920.

The mine of the Mass Consolidated Mining Co. was closed down late in 1919 and remained idle throughout 1920. The Mayflower-Old Colony Copper Co. continued its development work at an expense, including taxes, of $121,948 in 1920. There was a balance of $71,658 on hand on Dec. 31.

The Seneca Copper Corporation, a comparatively new comer in the Lake Superior district, is operating the Kearsarge lode on property formerly owned by the old Seneca Mining Co., and the Gratiot Mining Co. Final payment for the holdings of the latter company was made to the Calumet & Hecla Mining Co. in 1920. Development has opened the lode on five levels, and in 1920 497,680 lb. of copper was produced from this class of work.

An actual production of 855,267 lb. and an estimated production of 1,060,829 lb. of copper is reported by the Victoria Copper Mining Co. The company shows a net operating loss of $158,417.

Mine.	1918.	1919.	1920.	Mine.	1918.	1919.	1920.
Calumet & Hecla	$5,500,000	$1,000,000	$500,000	Ahmeek	$2,000,000	$600,000	$300,000
Copper Range Con.	2,366,394	986,016	591,626	Allouez	600,000	.....	*Nil*
Mohawk	1,000,000	500,000	550,000	Champion	1,970,720	1,280,000	600,000
Osceola	969,200	288,450	96,150	Isle Royale	375,000	150,000	*Nil*
Quincy	$935,000	440,000	110,000	Centennial	180,000	.....	*Nil*

Montana.—The mines of Montana produced about the same quantity of copper in 1920 as in the year previous, the State's output being 177,743,747 lb. compared with 176,289,873 in 1919. Although hampered by high costs, unfavorable market conditions, and serious labor difficulties, the mines were operated throughout the year, though on a reduced scale. The copper industry of the State is practically confined to the mines of Butte, where the Anaconda Copper Co. is predominant. This company

is not only the world's largest copper producer, but its increasingly varied industries promise to put it in a class by itself.

This company, operating at an average of 50 per cent. capacity in 1920, mined 2,160,320 tons of ore, including 435,000 tons of zinc ore and 65,000 tons of manganese ore, besides 7557 tons of copper precipitates from its mine-waters. Development work was continued, even in the mines that were not operated for ore production, and in sinking to a depth of 3950 ft. in the Stewart mine, 10 ft. of high-grade copper ore was encountered at 3850 ft., containing copper glance and bornite, a fact which argues well for the persistence of commercial ore throughout the camp at depths below those now being mined.

Operations of the Anaconda company for the year ended Dec. 31, 1920, show gross receipts of $100,295,167 and expenses of $92,275,001, or a gross income of $9,335,253, and net income of $2,691,660. Dividends paid from surplus amounted to $6,993,750.

Production for the year amounted to 155,339,575 lb. of copper, 7,113,659 oz. of silver, and 32,530 oz. of gold. The smelter at Anaconda, 27 miles from Butte, treated 2,319,336 tons of ore and other material, and the electrolytic refinery at Great Falls produced 145,149,892 lb. of copper cathodes. A copper leaching plant treating the tailings dumps from former milling operations handled 484,352 tons of tails and 43,271 tons of purchased ore, mainly from the Butte Duluth mine at Butte, and produced 10,074,000 lb. of cement copper.

The copper concentrator re-treated by flotation 722,769 tons of tails and 181,033 tons of slime from the tailing ponds.

The Great Falls plant produced 101,332,458 lb. of electrolytic zinc and the residue produced in these operations yielded 2,173,080 lb. of copper, 12,536,088 lb. of lead, 2,073,348 oz. of silver and 6,151 oz. of gold.

The bulk of the year's copper output went to the rod and wire plant of the company, at Great Falls, Mont., where it is made into merchantable material that brought 2½ cts. a lb. more than the cathode metal. Development work for the year totaled 22.55 miles, including 829 ft. of shaft-sinking, at the Stewart (406 ft.), Emily (303 ft.) and Silver Bow mines.

The North Butte company operated at about three-fourths capacity throughout most of the year, through its Granite Mountain and Speculator shafts producing 16,666,819 lb. of copper, 693,633 oz. of silver and 1004 oz. of gold, a slight increase of output over the 1919 figures, but at a cost of 17.64 cts. a lb. of copper compared with 14.85 cts. in 1919 and 20.19 cts. in 1918. The company's operations in the east side of the Butte district, about 2 miles east of the Anaconda mill, were continued, but at too high a level to reach the productive zone of the main ore-bearing veins of the Butte district. Development work on this tract for

3 years past includes a 900-ft. shaft and 10,000 ft. of cross-cutting and drifting. In the older properties development on the 3400- and 3600-ft. levels, though hampered by the heat of the rocks, has disclosed continuation of the high-grade ore-shoots of the Edith May, Adirondack and other veins mined above. Notwithstanding this fact, the shrunken ore reserves induced the directors to buy a heavy stock interest in the Shasta Zinc & Copper Co., owning the Bully Hill mines at Winthrop, Calif.

The Davis Daly company was one of the few properties that continued active operations without curtailment. The production for 1920 was 123,607 tons of ore yielding 13,654,064 lb. of copper, 902,979 oz. of silver and 319 oz. of gold, compared with the 1919 production of 7,903,961 lb. of copper and 517,162 oz. of silver from 74,551 tons of ore mined.

Development work has reached a depth of 2800 ft. in the Colorado shaft, and aggregated 10,149 ft. in 1920, exposing high-grade ore in three different veins.

The Tuolumne Copper Co. sank its Main Range shaft to a depth of 1600 ft. and continued operations at that mine on the 800- and 1000-ft. levels, shipping about 100 tons of ore per day, or a total for 1920 of 27,952 tons yielding 1,132,753 lb. of copper, 278,115 oz. of silver, and 210 oz. of gold, or an average of 2.026 per cent. copper, 9.95 oz. of silver and 15 cts. per ton in gold, all of which is paid for by the smelter. Net smelter returns for ores shipped up to Jan. 1, 1921, total $842,788. For the year 1920, smelter returns were $265,332, or $9.50 per ton, and total operating costs $8.48 per ton. It was one of the few companies in the country actually making an operating profit. Outside of the Butte district, there are a few promising properties in the development stage, notably the Boston & Montana mines at Brundy (Elkhorn), the Potomac Copper Co. near Missoula, and the Crystal Copper Co. mine on Cataract Creek, near Basin, the latter being a small and intermittent producer of both copper and lead ores. There are also a number of copper properties under development in the region along the Montana-Idaho line.

Nevada.—The State of Nevada produced 55,580,322 lb. of copper in 1920, with a value of about $9,500,000; for 1919 these figures were 51,067,000 lb. and $9,616,000 respectively. The rapidly declining price of the metal during the latter part of the year is here distinctly reflected.

White Pine County naturally heads the list, due to the fact that within its borders is the large porphyry copper property of the Nevada Consolidated Copper Co. This company produced 48,311,985 lb. of copper, an increase of more than 4,000,000 lb. over the total for 1919, but its net earnings for 1920 were nearly $1,000,000 less than the previous year. The output is derived chiefly from open pits by steam-shovels, but some part is produced from underground work in the Ruth mine. The con-

centrating plant and smelter are 22 miles distant in Steptoe valley, and connection is made with the mines by the Nevada Northern Ry., controlled by the Nevada Consolidated; the former has a daily capacity of 14,000 tons and the reduction works as a whole are complete in every way.

Ore reserves of the Nevada Consolidated at the end of 1920 were 63,845,631 tons of ore with a 1.58-per cent. copper content, of somewhat better grade than that of the ore treated during the year, which was 2,568,588 tons averaging 1.45 per cent.

The Consolidated Coppermines, with its mineral holdings in White Pine County also, was practically idle throughout 1920. During the first four months of the year some development work, including drilling, was performed in the Alpha and Taylor mines, but operations were more and more curtailed, and ceased at the end of the year. This company has planned to erect a 2000-ton concentrator and a 500-ton reverberatory furnace at a total estimated cost of $2,500,000.

The Copper Canyon Mining Co., with two mines in Lander County, was not in the producing class during 1920, but continued development of its orebodies at Copper Basin near Battle Mountain, and reported that its reserves amounted to 1,214,460 tons of 2.4-per cent. copper ore.

The Yerington district of Lyon County was responsible for about 1,000,000 lb. of the Nevada production, but both in this and in Mineral County copper mines were much handicapped by the idleness of the Mason Valley Mines Co. smelter at Thompson. The Nevada properties of the latter company have been generally inactive since early in 1919, although development of its mines in California has been continued. Shipments, however, have been delayed pending a decision on freight-rates by the Interstate Commerce Commission. A reduced rate may make it possible to blow in the Thompson smelter, as the ore reserves of the company's California holdings may be expected to supply sufficient ore to keep the smelter in operation.

New Mexico.—Recently this State has held the sixth position as a copper producer, but in 1920 it was superseded by Alaska. A preliminary estimate reports the total production to have been 52,159,751 lb., compared with 64,683,734 lb. in 1919.

The Chino Copper Co., operating one of the so-called "porphyry coppers" at Santa Rita, produced nearly 85 per cent. of the total, or 44,051,849 lb. of copper, a slight increase over the 1919 figures. Mining operations are conducted by steam-shovels, which in 1920 handled 2,522,135 cu. yd. of overburden, and mined 2,332,730 tons of ore with a copper content of 1.53 per cent., and at a cost of 92.81 cts. per ton of ore.

At the mines the company has 24 miles of track and a primary

crushing plant, from which the ore is shipped by railroad to its concentrating plant at Hurley, 9 miles distant. In 1920 this plant treated 1,838,140 tons of ore, an average of 5022 tons per day, having a copper tenor of 1.76 per cent.; 142,446 tons of 16.09-per cent. copper concentrate was produced; the milling cost was $1.43 per ton of ore. The ore reserves at the end of 1920 were 105,689,247 tons.

The Bonney Consolidated Copper Co., in Grant County, although not a producer either in 1919 or 1920, has continued development and increased its ore reserves by a few thousand tons in the latter year. The Cecto Mining Co., with holdings in the same county, was engaged also in development work throughout the year, reaching a depth of 300 ft. The ores of these two companies carry silver as well as copper.

The Calumet & Arizona Mining Co. in June purchased the property of the Eighty-five Mining Co. situated in Hidalgo County. Since its acquisition some 5600 ft. of development has been performed and 30,000 tons of ore carrying 2.6 per cent. copper has been shipped.

At Fierro, the Hanover Bessemer Iron & Copper Co. continued to ship iron ore at the average rate of 25,000 tons per month; it has large reserves not only of 55-per cent. iron ore, but also of ores carrying 40 per cent. iron and 1 per cent. copper. The company is controlled by the United States Smelting, Refining & Mining Co.

The Burro Mountain mine, at Tyrone, owned by the Phelps Dodge Corporation, yielded 231,152 tons of 2.043-per cent. milling ore that produced 25,669 tons of 13.182-per cent. concentrate, or 6,509,128 lb. of metallic copper and 22,365 oz. of silver. Development work included 34 drill holes, one of which showed 125 ft. of good ore. The ore reserves show a small net increase.

Oregon.—The entire copper production in Oregon was credited to Baker County. The 1920 total was 2,529,311 lb., compared with 2,638,714 lb. in 1919. The Iron Dyke mine, the largest copper producer of the State, operated steadily throughout 1920, shipping about 800 tons of concentrate per month.

It is expected that the mineral industry of Oregon will be stimulated by resumption of operations by the Sumpter Valley Smelter Co. Plans were being perfected during 1920, and actual blowing-in will take place sometime in the next year.

Tennessee.—This State alone of the Southern States is a copper producer of consequence, the metal being entirely derived from mines in the southeastern corner of its territory. Georgia, as a usual thing, and North Carolina less often, do appear in the producers' column, but their limited production comes only from extensions of the Tennessee copper field.

The copper deposits of Tennessee have been known and operated for 70 years, and despite their low copper content cheap fuel and relatively cheap labor have made it possible to exploit the ores at a profit.

The operations of the Copper Pyrites Corporation are still in an experimental stage, but the Ducktown Sulphur, Copper & Iron Co., Ltd., and the Tennessee Copper Co. were operating as usual in 1920. Both companies make sulphuric acid from waste smelter gases.

The Ocoee Copper Co. reports having made important developments; its property adjoins that of the Ducktown company and drilling has indicated that the latter's orebody extends downward beneath the Ocoee holdings.

Preliminary figures indicate that the total copper production of Tennessee for 1920 will be approximately 17,000,000 lb.

Utah.—For several years past, Utah has held fourth position among the copper-producing states of this country. In 1920 the total production was 110,357,748 lb., compared with 146,178,088 lb., valued at $23,242,000, in 1919. This decrease in output must be charged against the smaller companies, as the production of the Utah Copper Co. in 1920 was only about 3,000,000 lb. less than in the year before. This company operates the largest developed orebody of the world, excepting only the Chuquicamata mine of the Chile Copper Co., its ore reserves at the end of 1920 being 364,130,800 tons, with an average copper content of 1.35 per cent. This huge enterprise covers 851 acres of mineral and 11,204 acres of other lands, and about one-quarter of the former is known to contain mineralized porphyry of commercial value.

Mining operations are conducted entirely by the open-pit system and involve the stripping of an oxidized capping of too low grade for profitable treatment. Thus, during 1920, 2,938,299 cu. yd. of this material was removed, bringing the grand total to 53,044,034 cu. yd. since stripping operations were first begun. During the year, the steam-shovels mined 5,556,800 tons of concentrating ore, at a cost of 48.23 cts. per ton, of which 12.5 cts. was chargeable to stripping operations. In addition to the porphyry ores, 187,265 tons of carbonate ore were shipped to the leaching plant.

The Utah Copper Co. has two mills at Garfield, 20 miles from the mine, but only the 16,000-ton Arthur plant was operated during 1920 and treated the entire mine output of porphyry ore. The average grade of this ore was 1.16 per cent. copper, of which the mill recovered 81.38 per cent., at a cost of $1.25 per ton of ore. The net copper production was 101,897,758 lb. The Bingham & Garfield Ry., 134 miles in length, is controlled by the mining company and connects mine with mill, and the latter with smelter, one mile away.

In 1920 the net profit of this company was $4,924,498, which includes dividends from the Nevada Consolidated Co., controlled by the Utah Consolidated through stock ownership. This is at the rate of $3.03 per share as against the 1919 figure of $5.08. As was the case in 1919, the Utah Copper Co. during much of 1920 operated at about 50 per cent. capacity, but dropped to 40 per cent. towards the end of the year.

In the middle of 1920 the Utah Consolidated Mining Co. began the construction of a 1000-ton flotation plant to cost $500,000, and to be completed by April, 1921. This company, which is also a silver-lead producer, reports an output of 102,174 tons of ore for 1920, from which 2,187,492 lb. of copper was recovered. The reserves of copper ore at the end of the year were 815,000 tons, averaging 1.96 per cent. copper. Litigation between this company and the Utah Apex Mining Co. was decided in favor of the latter; the financial adjustment is still pending.

The Western Utah Mining Co., operating in Tooele County, was a small copper producer, as were also some of the properties of the United States Smelting, Refining & Mining Co.

The copper smelting plants, with which Utah is well supplied, did not have a particularly satisfying year.

Washington.—In 1920 this State stood eleventh on the list, with a copper production of 2,125,586 lb. The output has not varied materially for the past five years.

The United Silver-Copper Mining Co., with mines in Stevens County, in 1919 shipped 922,227 lb. of copper, largely in the form of concentrate. Early in 1920 this rate of production continued, but the mine was practically closed down during the last months of the year. In Snohomish County the Sunset Copper Co. operated on a small scale for 10 months, but the Copper World Extension Mining Co. in Okanogan County, something of a producer in the past, was developing by drilling and no shipments are reported. The Loon Lake mine is in the hands of receivers and was idle in 1920.

The mining industry of Washington is supplied with smelting facilities by the Tacoma plant of the American Smelting & Refining Co., which operated continuously throughout the year.

Other States.—Little need be said of those states that are not listed separately. Pennsylvania, ranking first, produced 618,361 lb. of copper derived presumably from pyritiferous magnetite ores. The copper production of Missouri was 533,368 lb., nearly all of which is a by-product from lead concentrating plants. Texas and Wyoming had outputs of 14,217 and 24,256 lb., respectively.

The only other copper-producing states recorded for 1920 were

Georgia and South Dakota. In North Carolina the old Ore Knob mine was the subject of renewed investigation.

Copper Mining in Foreign Countries

But few of the foreign nations can be said to have found the copper market conditions for 1920 in any degree satisfactory. The worst sufferers were apparently Japan and Spain, with Australasia and Africa following closely, but each showing a copper production slightly improved over that of 1919. Chile stands in a class by herself, and in 1920 reports a 50-per cent. increase in the production of copper over the figure for 1919.

Africa.—Exploitation of the base metals in Africa is of much less importance than gold and diamond mining. On the other hand, the Belgian Congo can boast that its territory includes what is probably the largest individual producer of copper outside of the American continent. Of the total African production for 1920, 32,230 tons, the Union Minière du Haut Katanga, operating on the Katanga copper belt, is responsible for nearly five-eighths, or 18,962 tons, some 4000 tons less than that reported for 1919. Its ore reserves amount to 32,300,000 tons, or, measured by metal content, 1,869,500 tons of copper. The company's furnace has an extreme capacity of 40,000 tons of copper annually, and it is expected that by June, 1921, its new 4000-ton concentrator, which with connecting railways, mine development, etc., will cost about $16,500,000 (par exchange), will be in operation.

To emphasize the scale of operations, it may be stated that the ore extracted during 1919 from the company's three mining centers amounted to 876,000 tons, plus 316,000 tons of overburden; of the ore total, 189,000 tons was of smelting grade, while 360,000 tons was stocked for concentration and 327,000 tons for future treatment, presumably by leaching, if the experiments under way should prove successful.

Of the Cape Copper Co. little need be said as to its African activities; mining operations were suspended in May, 1919, except that prospecting by drilling still continues. Early in 1920, this company had copper ores and metal in stock valued at more than $1,000,000. A $600,000 bond issue was authorized in November, 1920. Note is made as to this company's operations in India under that sub-title.

The Namaqua Copper Co., also operating in the Cape Province, due to the high cost of freight and fuel allowed its smelter to remain idle during 1920 as in 1919. In the latter year the precipitate produced was equivalent to 103 tons of copper, and its ore reserves (Jan. 1, 1920) to 3384 tons.

In Rhodesia the Falcon Mines, Ltd., produced during the 18 months

ending December, 1920, 4262 short tons of copper from 260,863 tons of ore; the ore reserves on this date were 515,000 tons.

Argentina.—In Argentina, the Corporacion Minera de Famatina, a reorganization of an older company with similar name, overhauled its 200-ton smelter and was operating during the latter months of 1920. Its mines are located in the Department of Chilecito, and the ore is reported to carry 5.5 to 6 per cent. copper.

Australia.—During 1920 the production of the Commonwealth was 24,069 tons of bar copper, 2002 tons of blister and 115 tons in ores exported. Home consumption for the same period was 5231 tons of bar copper. Refined copper exports amounted to 28,612 tons.

In Queensland, the most important producing State, although the copper output was distinctly greater than in the previous year, the improved market conditions of late 1919 carried over only until the end of February 1920; the price declining from £122 per ton in that month to £72 in December. The Mount Elliott, Ltd., was shut down during the entire year and the Mount Cuthbert smelter for 3½ months; the latter reports ore reserves of 40,000 tons in its parent mine and the opening of a new shoot of 10-per cent. ore in the Orphan mine. In the case of the Hampden Cloncurry company, its Trekelano mine has a monthly output of 2500 tons of 12-per cent.

PRODUCTION OF COPPER IN AUSTRALASIA
(In tons of 2240 lb.)

Year.	New South Wales.				Queensland.		South Australia.		Tasmania.			Western Australia.		
	Ingots, Matte and Regulus.		Ore.		Copper, Tons.	Value.	Copper, Tons.	Value.	Blister Copper.		Copper Ore.	Copper Ore, Tons.	Copper, Tons. (a)	Combined Value.
	Tons.	Value.	Tons.	Value.					Tons.	Value.	Tons.	Value.				
1911	10,618	£578,198	1,432	£11,904	20,384	£1,151,351	5,922	£332,500	6,022	£335,797	2,286	£22,852	9,825	829	£78,364
1912	8,990	560,025	2,044	19,766	23,120	1,698,280	6,295	461,800	5,136	430,965	1,392	9,479	13,607	1,703	120,158
1913	9,153	595,826	308	2,907	23,655	1,660,178	7,161	488,986	4,569	364,332	1,967	10,932	4,339	82	145,513
1914	3,500	274,671	3	11	18,436	1,118,648	6,881	417,487	7,509	477,361	3,288	18,680	3,913	183	38,174
1915	6,973	.....	Nil	Nil	19,704	1,428,793	7,725	561,247	7,901	709,167	66	367	737	946	91,169
1916	6,171	.....	Nil	Nil	19,520	2,265,422	7,279	822,527	6,305	884,089	97	1,765	650	457	64,833
1917	6,576	714,154	Nil	Nil	19,062	2,208,232	7,213	902,495	5,845	811,583	771	6,171	966	535	85,738
1918	6,510	696,580	Nil	Nil	18,980	2,087,751	7,169	828,556	5,559	772,162	444	3,944	1,643	478	66,146
1919	1,460	139,296	Nil	Nil	9,997	952,501	2,517	228,930	5,027	504,961	.....	.....	455	4	10,105
1920	1,290	127,978	Nil	Nil	15,897	1,551,995	3,874	423,601	4,792	528,237	.....	.....	.....	.....	.....

(a) Ingots and matte.

ore. The Mount Morgan smelter treated 109,720 tons of ore, yielding 6263 tons of copper, not including the copper content of low-grade fluxing ores also treated.

Bolivia.—This country produced 9900 tons of copper in 1920, a gain of about 3000 tons over the 1919 figure. The Corocoro United Copper Mines, Ltd., and the Cia Corocoro de Bolivia, operating in the Corocoro district of central Bolivia, are probably the more important producers. The former reports an output of 6550 tons of copper for the 12 months ending June, 1920, in the form of ore and concentrate.

Canada.—The copper production in 1920 amounted to 81,155,360 lb., which at the average price (New York) of 17.456 cts. would have a total worth of $14,166,479, as compared with 75,124,653 lb. produced in 1919, with an average price of 18.691 cts. per lb. and a total value of $14,041,549. Of this total, 78.1 per cent. was produced by Canadian smelters, the remainder being recovered from ores sent to the United States for treatment. Much the larger part of Canadian blister is sent to the United States for refining, and thus the Canadian plants in 1920 were credited with a total production of refined copper of only 2620 tons; this compares with 3487 tons for 1919.

Of the provinces British Columbia was as usual at the front with a 1920 production of 45,344,434 lb. valued at $7,915,324; these figures for 1919 were 44,388,934 lb. and $8,296,735, respectively. This production included 28,464,073 lb. of copper in the form of blister, refined and sulphate, and 16,880,361 lb. estimated to have been recovered from ores sent to the United States for treatment.

Ontario produced a total of 31,980,067 lb. of copper having a value of $5,582,440, as against 24,361,934 lb. valued at $4,443,489 in 1919. The nickel-copper ores of the Sudbury district were as always mainly responsible for this production.

In Quebec the Department of Mines reports a production of 768,282 lb. of copper in 1920, or less than one-third of that recovered in 1919; its value was $134,111. This copper is derived as a by-product from pyritic ores principally valuable for their sulphur content.

The production of Manitoba in 1920, as in 1919, came wholly from the mine of the Mandy Mining Co. The high-grade ore-lens was exhausted and work suspended in 1919, but final shipments amounting to 7510 tons of ore, or 3,000,000 lb. of copper, were made in 1920. Development of the large low-grade copper deposit on the Flin Flon property was continued and $400,000 was expended on underground work in 1920.

According to the Department of Mines there is no record of any copper production in the Yukon, although in 1919 334,090 lb. valued at $62,445 was obtained.

The copper exports from Canada in 1920 were: copper in ore, etc., 23,665 short tons, valued at $5,917,782; blister copper 19,099 tons, valued at $8,701,184; copper in pigs, bars, sheets, etc., 1,332 tons, valued at $710,978; and copper "old and scrap," 387 tons, valued at $113,265, giving a total of 44,485 tons, valued at $15,444,209, besides copper wire and cable valued at $433,097. The total exports in 1919 were 41,058 tons valued at $14,654,640.

The imports of copper in ingots, bars, etc., and in manufactured form in 1920 were valued at $4,558,234, as against a reported value of $3,599,297 in 1919. The quantity imported in 1920 would approximate 10,500 tons, as against 10,000 tons in 1919.

In British Columbia, the Britannia Mining & Smelting Co. produced 17,500,000 lb. of copper, and is reported to have ore reserves as of Dec. 31, 1920, of 9,000,000 tons averaging about 2 per cent. copper.

The Granby Consolidated, operating at Anyox, the largest copper smelter in the British Empire, produced 23,127,849 lb. of copper. This company has had to rely on bond issues to carry it through the general market depression following the Armistice.

In October of 1920, the Canada Copper Corporation began operations at its new concentrator at Allenby, B. C. This undertaking involved the construction of a 12-mile railroad connecting the mill with the mine at Copper Mountain, and a total outlay of $7,000,000.

The Consolidated Mining & Smelting Co. apparently experienced a moderately satisfactory year and at the end of 1920 reported a net profit of $291,395. Among its many activities the smelter at Trail produced 4,501,594 lb. of copper. This company operates the only copper refinery in Canada.

Chile.—For the second time in her existence as a copper producer, Chile stands second to the United States, with a total production in 1920 of 94,531 tons; this compares with 63,930 tons for 1919.

The Chile Copper Co. through its subsidiary the Chile Exploration Co. is operating the Chuquicamata copper deposit, the largest known in the world, with a maximum length and width of 7500 and 2200 ft., respectively, and with an estimated average copper content of 2.12 per cent. The reserves, covering both oxidized and sulphide ores, were 694,550,866 tons at the end of 1919. Mining operations are conducted by the open-cut method, and the equipment, including 11 power-shovels, is complete to handle 15,000 tons of ore per day. Copper is recovered by leaching, and in 1920 the average extraction was 92.12 per cent., an increase of 4 per cent. in two years.

The 1920 production of this company was 55,565 short tons of copper, as against 38,359 tons in 1919; the cost of production, exclusive

of depreciation and depletion, for these two years was 10.7 and 13.01 cts. per lb., respectively. The company reports that the development stage has now been passed. There was a net surplus from operations of $151,994 in 1920, compared with a loss of $2,290,658 in 1919.

The Braden Copper Co., a subsidiary of the Braden Copper Mines Co., which in turn is controlled by the Kennecott Copper Corporation, owns the Teniente mines, 40 miles from Rancagua, covering five known orebodies. The reserves at the end of 1920 were 176,640,000 tons of 2.45 per cent. copper positive ore and 87,750,000 tons of 1.87 per cent. copper probable ore. By the end of 1920, the company hopes to have completed its 10,000-ton concentrator now being erected at Sewell in conjunction with the smelter plant. The production for 1920 was 64,918,298 lb. of blister copper as against 47,000,000 lb. in 1919. The operating profit for 1920 was $2,092,258, but there was a deficit after all charges of $2,079,988. Although operating for 15 years, this company has been unable to make a profit for its stockholders, and the Kennecott has alone advanced nearly $12,000,000.

At Chanaral, the Andes Copper Mining Co., a subsidiary of the Anaconda Copper Mining Co., is developing the Potrerillos mine. The orebody is 900 by 1800 ft. in area and has a depth of 850 ft., and at the end of 1919 the total tonnage developed amounted to 120,000,000 tons of 1.48 per cent. copper. Railways have been built and the mine partially developed, but installation of mill and smelter has been delayed. The Anaconda Copper Mining Co. also controls the Santiago Mining Co., which is developing Lo Aguirre and Africana mines 12 miles west of Santiago. The copper ores, both sulphides and oxides, of the former occur as a disseminated deposit. As far back as 1918, 6,000,000 tons had been developed, but estimates of probable tonnage were considerably greater.

There are a number of other mining companies which have in the near past contributed quite a little to the copper production of Chile, but since the war conditions have been such that their activities have been very much curtailed or suspended entirely. The Société des Mines et Usines de Cuivre de Chanaral, with a smelter, the Société des Mines de Cuivre de Catémou, with a 1918 production of 4500 short tons of copper, and the Société des Mines de Cuivre de Naltagua, with an output of 4000 tons in 1918, may be mentioned.

Cuba.—In 1920 the production of copper in Cuba totaled 20,000,000 b., all from the Matahambre mines, and all shipped to the United States in the form of ore and concentrate for treatment. Imports from Cuba into the United States since 1912, in long tons, are as follows:

Year.	Ore.			Concentrates.		
	Tons.	Value.	Value per Ton.	Tons.	Value.	Value per Ton.
1912	75,576	$727,229	$9.62	.....	.....	.....
1913	35,905	676,245	18.84	.....	.....	.....
1914	29,177	1,270,182	43.53	.....	.....	.....
1915	61,080	2,680,268	43.88	.....	.....	.....
1916	69,789	4,846,995	69.46	6,900	$381,236	$55.25
1917	86,824	5,824,698	67.10	8,000	469,168	58.65
1918	78,681	4,041,058	51.36	11,540	896,040	77.65
1919	65,001(a)	4,532,648	69.73	.....	.....	.....
1920	58,890(a)	3,020,612	51.29	.....	.....	.....

(a) Including concentrates.

France.—Since France is a non-producer of copper, imports are relatively large. In 1920 France purchased from the United States alone 118,489,000 lb. of copper, or 7.6 per cent. of the entire production of the latter country.

Germany.—According to an important technical journal, this country between the years 1879 and 1913 produced only 4 per cent. of the world's copper for these 35 years; as her consumption is large, Germany falls into the importers' class. And as a matter of fact her standing as a producer has declined in recent years, due presumably to high labor costs. In 1920 Germany's copper production was 17,255 tons, compared with 25,300 tons in 1913 and 28,632 tons in 1917.

Of the Mansfeld Copper Mines, at Eisleben, which produced 10,605 tons of copper in 1919, no information is available, other than the fact that the year was satisfactory.

Germany since the war has not apparently relied on copper substitutes to the extent predicted, and, as will be noted under the heading "Exports," its purchases of copper from the United States in 1920 were quite substantial, the average monthly imports being only a little less than one-half the pre-war rate.

India.—In this country, the Cape Copper Co., having suspended its operations in Africa, mined and treated 35,540 tons of 3.57-per cent. ore at its Rakha Hills mines, Chota Nagpur, in 1920, and the metallurgical plant with a capacity of 250 tons of copper was completed at the close of the year. The reserves amount to 354,688 tons of 3.66-per cent. copper ore. The Cordoba Copper Co., Ltd., originally operating in Spain, has taken a working option on 20 sq. miles of the Cape company's property and exploratory work was performed during 1920.

Japan.—The copper production in Japan for 1920 amounted to 65,554 tons, as against 82,073 tons in 1919, 94,455 tons in 1918 and 122,562 tons in 1917. Despite this curtailment, Japan was still one of the three largest copper-producing countries.

COPPER EXPORTS OF JAPAN
(In long tons)

	Europe.	America.	China.	Hongkong.	India.	Totals.
1910	21,116	8,846	957	.....	4,218	35,137
1911	17,288	11,009	3,688	.....	2,332	34,307
1912	23,351	6,917	7,317	.....	805	38,390
1913	19,843	5,543	13,320	.....	3,574	42,280
1914	19,642	5,207	13,577	.....	3,274	41,700
1915	45,140	7,800	1,430	.....	1,220	56,000
1916	53,796	2,921	1,577	52	86	58,432
1917	59,070	2,617	4,910	205	3,916	70,778
1918	20,666	37	7,392	1,220	2,427	31,435
1919	2,501	*Nil.*	13,640	1,550	1,371	19,062
1920	655	*Nil.*	4,007	*Nil.*	473	5,135

As was the case during the last 8 months of 1919, Japan continued to be a large importer of copper during the first half of 1920, purchasing in that period about one-fifth of the total copper exported from the United States, although from July 1 to the end of 1920 imports by Japan from the United States practically ceased.

Copper stocks on hand in Japan on Dec. 31, 1920, amounted to 27,500 tons.

Mexico.—In spite of chaotic political conditions, Mexico produced 50,663 tons of copper in 1920 and even more, 60,491 tons, in 1919. In Baja California, the Boleo Copper Co. under French control produced steadily throughout the year at a slightly diminished rate, with a total of about 5300 tons of copper. This company has operated for 35 years and paid dividends for 28. The Democrata Cananea Sonora Copper Co., in Sonora, reports a production of 1730 tons in seven months, when operations were suspended to await a better market.

The two more important copper producers of Sonora are the Greene Cananea Copper Co. and the Moctezuma Copper Co., of the Phelps Dodge Corporation, with records for 1920 of 21,836 and 11,614 tons, respectively. The former is actually a holding corporation controlling a group of mining companies situated at Cananea not far from the United States boundary, and comprising 34,738 acres of mineral and 322,123 acres of surface lands. There are three principal mines, which have large deposits both of smelting ore and of the disseminated type. Other mines also have important orebodies. The yearly development keeps the ore reserves at a constant figure. The property is equipped with a 2800-ton concentrator, a large smelting plant, a 36-mile railway, etc. The company's net earnings for 1920 were $560,078, from which dividends of $1 per share were paid. The cost of copper production was 16.304 cts. per lb.

The Pilares mine of the Moctezuma company is situated at Nacozari, which with other mineral lands aggregates 2500 acres; there are 35,000

acres of ranch lands additional. The ore reserves at the end of 1920 were somewhat greater in amount and of better average grade than those of the previous year. The concentrator handled 453,880 tons of 3.12-per cent. copper ore with an extraction of 86.49 per cent.

In the State of San Luis Potosi, the Dolores mine of the American Smelting & Refining Co. contains large irregular contact deposits of copper ore averaging from 2 to 3 per cent. Its normal production is 600 tons of ore per day, which is shipped to the company's smelter at Matehuala. The Mazapil Copper Co., Ltd., operates copper mines in Zacatecas and in 1920 was reported to be shipping 15,000 tons of ore to its smelter and producing 350 tons of copper matte per month.

Peru.—This is the only important copper-producing country of South America other than Chile. The reported production of Peru for 1920 is 31,276 tons, as against 39,470 tons in 1919. The larger part of this total was due to the Cerro de Pasco Copper Corporation, with an output of 63,128,000 lb. of copper in 1920 and 58,128,000 lb. in the previous year. This company's metal sales, including copper, silver and gold, amounted to $11,463,572, with a surplus income of $618,433; $3,592,917 was distributed in dividends in 1920. This company is now constructing a new 2500-ton smelting plant at Oroya. The relatively lower labor cost and high silver content of the ore permits the Cerro de Pasco to continue production at 75-per cent. capacity despite the existing depressed metal market, and an $8,000,000 bond issue late in 1920 should supply sufficient funds for it to carry its copper production.

The Societa Minera Backus y Johnston del Perú reports the production of 16,268,273 lb. of copper for 1920 from its mines in the Morococha and Casapalca districts. In 1919 its output was 21,679,514 lb. This company's ore also yields considerable silver.

As recorded in MINERAL INDUSTRY for 1919 the Peruvian Copper & Smelting Co. has been engaged in developing its extensive mineral holdings in the Yauyos district, and at the end of 1920 had ore reserves of 400,000 tons of ore, averaging 16 per cent. copper, and 3,000,000 tons of probable ore. The company has a 100-ton smelter which it contemplates enlarging to 300 tons.

Russia.—If the vast resources of Russia (inclusive of Siberia) were properly exploited, this country would doubtless take high rank as a copper producer, but under existing conditions there seems but little hope of any immediate change in her position.

As in the case of 1919, no figures of production are available for 1920. It should, however, be noted that the Kyshtim Corporation, Ltd., operating in the Urals, was with other companies merged into the Russo-Asiatic Consolidated, Ltd., in 1919. Prior to the merger, the properties

of the individual companies were in 1918 confiscated by the Soviet Government. Claims totaling £56,000,000 have been filed with the British Foreign Office.

Serbia.—Always somewhat of importance as a copper producer, Serbia is reported to have yielded 2436 tons in 1920. The copper mines of this country were operated by the Central Powers during the war, and although damaged to some extent it is understood that recuperation has been rapid.

Spain and Portugal.—These two countries may be grouped, as the important copper district of southern Spain extends across the border into Portugal. The 1920 production was 25,000 tons of copper as against 40,000 tons in 1919; of this total Portugal should probably be credited, as in former years, with only about one-seventh.

Particulars regarding the output of the Rio Tinto Co., Ltd., are not revealed, but during 1920 this company suffered seriously from labor troubles which began in July and continued for two or three months. Perhaps for the first time in its history, the company failed to declare a dividend. The balance carried forward is, however, £26,000 greater than at the end of 1919, or a total of £375,000.

The Tharsis Sulphur & Copper Co., Ltd., ships cupriferous pyrite cinder to the British Isles for treatment, and its 1920 output for this product was above the average. A net profit of £134,949 is reported. The Huelva Copper & Sulphur Mines, Ltd., produced 1649 metric tons of copper for the 12 months ending June, 1920.

In Portugal, Mason & Barry, Ltd., operate the San Domingas mine and in 1920 extracted 93,812 tons of cupriferous pyrite ore, with a net profit of £67,685.

Sweden and Norway.—The copper production of these two countries for 1920 was 4900 tons, of which Norway's quota was 1400 tons. In 1919 the figures for Sweden and Norway were 3271 and 1800 tons, respectively. The Sulitjelma Aktiebolag, with mines in Norway but controlled in Sweden, produced 85,000 tons of cupriferous pyrite. At Meldalen, Norway, the Orkla Grube-Aktiebolag, which has been making very considerable increases in equipment, was presumably a non-producer in 1920, as was also the Foldal Copper & Sulphur Co., Ltd., which owns a cupriferous pyrite deposit at Foldal, Norway.

The Metallurgy of Copper in 1920

By L. S. Austin

Progress In 1920

General Conditions.—With copper at 15 cts. per lb., it may be said to be selling at a cent below the average cost of production for 1919. Since then coal and freight rates have advanced at least 25 per cent., thus further discouraging producers. Add to this a heavy stock of copper, say 600,000,000 lb., all tending to slow up production, and calling for the borrowing of large sums to carry it. The hope for the immediate future lies perhaps in the repeal of the excess-profits tax, but at any rate on a re-adjustment of wages and supplies. Wages in the mining camps have been cut by 20 per cent. at least. The Granby Consolidated M. S. & P. Co. for instance is producing copper at 14 cts. per lb., including bonded indebtedness and taxes, which is pretty close to its 15-ct. selling price. The Chino Copper Co. only breaks even, and the Utah Copper Co. shows a cost of 17.156 cts. in the third quarter of 1920, as compared with 13.7 cts. in the second quarter and 13.2 in the first quarter. What is true of these companies is true of all, that on diminished production, overhead expenses remaining, there is, even for normally flourishing companies, little profit left.

The production of the United States for 1920 may be given at 1,500,000,000 lb., or 300,000,000 lb. less than in 1919. It is felt, however, that the present crisis is temporary, and that upon re-adjustment, we may hope for renewed activity accompanied by economies in operation. Thus the Copper Queen company proposes to spend $3,000,000 to $4,000,000 in improvements at its reduction works at Douglas as the result of successful experimental work there.

Smelter output, which was increased due to the exigencies of the Great War, has dropped back to that in 1914, or to 60 per cent. of full capacity, and still production may be said to be in excess of demand. One feature in depressing prices is due to the large amount of scrap copper sold back to the United States by both England and France, and which may take three months to be absorbed. This scrap is left over from the war as shell-castings, cartridge-casings, etc.

"It is hard to foresee that improvements can be expected in 1920, but the quantity of copper sold in the early part indicates that the year will be better than 1919. Any improvement, however, will be temporary and no stability or security can be found until existing troubles are settled and trade becomes more stable. The prosperity of the copper industry is peculiarly dependent upon the establishment of stability in other industries, and before the copper industry can receive any great stimulus the condition of labor and of trade generally, not only in America but in

Europe, must be greatly improved. When that time comes the industry will undoubtedly be as prosperous as ever."

The striking development during 1920 is in the application of pulverized coal to use in the blast-furnace, a development that has great possibilities in the saving of fuel. In the multiple-hearth furnace more hearths are used, as many as nine or ten having been put in. In the hydrometallurgy of copper, liquid sulphur dioxide is being applied to the precipitation of copper from the leached solution. At Ajo, Ariz., cement-copper is agitated with electrolyte solution containing iron, so as to reduce it to ferric form. The solution, thus purified, is again sent to the electrolytic tanks. The Cottrell system of electrolytic precipitation of smelter dusts has been extended, notably at the extensive installation of the Anaconda Copper Mining Co., where the results have been gratifying. The sintering of flotation concentrate has been successfully carried on, and the smelting of the product in the blast-furnace follows.

Copper Smelteries Closed in 1920.[1]—Due to decreased demand for copper and to rising costs of production, a number of smelting works of copper-producing companies have closed down. Among these in the United States are:

The Clifton smelter, Clifton, Ariz., of the Shannon Copper Co.
The plant of the Calaveras Copper Co., Copperopolis, Calif.
The Benson plant of the Arizona Smelting and Power Co.
The Mason Valley smelter, Thompson, Nev.
The Ouray furnace at Ouray, Colo.
The Penn Mining Co.'s plant, Camp Seco, Calif.
The Morenci plant, Morenci, Ariz., of the Phelps-Dodge Co.
The Mammoth Works, Kennett, Calif.
The Mountain Copper Co.'s smeltery at Martinez, Calif.
The blast-furnace plant at Cooke, Mont.

In Canada there are:

The works of the Canadian Copper Corporation, Greenwood, B. C.
The Granby works, Granby, B. C.
The Ladysmith smeltery.

The British America Nickel Corporation's smeltery and refinery was blown in, but operated at less than capacity.

In Mexico the smelteries operated fractionally in 1920.

Roasting and Dust-recovery

Nine-hearth McDougall Roaster.—One of these furnaces has been put in at the Copper Queen reduction works and successfully operated.

Nodulized Fines.—At Chrome, N. J., where nodules for blast-furnaces have been prepared for several years, these have been flattened between rolls, thus making a better smelting product.

[1] *Eng. Min. Jour.*, **111**, 144 (1921).

Concrete Hearths for Roasting Furnaces.[1]—In an editorial and discussion of such hearths, W. W. Taylor records a speedy failure at the works of the Braden Copper Co., Sewell, Chile, while Frank R. Corwin declares they have been a great success at the works of the Anaconda Copper Co. at Great Falls. It would appear that failure must have been due to improper materials and proportions. At the Braden works a mixture of cement and granulated slag was used in the proportion of 1 of cement to 2½ of slag. Temperatures were carried to 1200° C., or to above the formation temperature of the slag, so that failure might have been predicted. In the editorial comment it was suggested that the proportions were wrong, and that there was no sand as generally used in a concrete mixture. Mr. Corwin declares in favor of the concrete hearth because experience has, according to him, shown its greater permanence and lower cost as compared with the brick hearth. A. E. Wiggin, general superintendent at Great Falls, states that the concrete hearths put in in 1912 were in continuous operation until April, 1919, when the roasters were shut down.

The Bradford Process.—This process, worked up by D. and R. H. Bradford, consists essentially in giving a chloridizing roast to the crushed ore, copper being driven off as a fume of copper chloride, this fume being then recovered by a Cottrell treater. The deposited fume is treated with addition of coke and quick-lime to yield metallic copper. The low-grade ore is crushed to 12-mesh size, common salt is fed into the crushed ore in proper proportions, and the mixture delivered to a chloridizing furnace by plunger-feed, where it is brought to a dull red-heat. The copper oxides and sulphides react with the salt, giving copper chloride volatile at the temperature of the furnace. This fume is drawn off by an Ilg ventilating fan to a Cottrell treater. Here it is precipitated electrostatically by a uni-directional current at 65,000 volts. The precipitated fume, removed from the treater from time to time, is taken in closed cars to a mixing floor where a proper addition of lime and cake is made, and the charge is introduced into a "bullion furnace." Upon melting the charge, the lime reacts with the copper chloride, setting free the chlorine, while the carbon reduces the copper to metallic form. We get two products, metallic copper and a residue from the gangue contained in the fume. The copper is separated or concentrated from the gangue, the residual tailings being sluiced to the dump. The process is at present in operation at the Pope-Shedon mine, Salmon, Ida., in a mill of 50 tons capacity.

Cottrell Plate-type Apparatus at Tooele, Utah.[2]—The smoke from the

[1] *Eng. Min. Jour.*, **110**, 799, 802, 411 (1920).
[2] *Trans. Am. Inst. Min. Met. Eng.*, Aug., 1920; *Min. Sci. Press*, **121**, 273 (1920); private notes; *Chem. Met. Eng.*, **23**, 249 (1920).

32 McDougall roasters discharges into a dust-chamber, and is carried thence by flue to the roaster stack. Roesing wires were formerly hung in the chamber for catching the dust, but proved unsuccessful, due to the interference of wires, to their corrosion, and to the occasional fall of a loose wire into the hoppers. The wires were therefore removed and replaced by the Cottrell installation below described.

Precipitation in a Cottrell treater is generally effected on the inner surface of tubes of about 12-in. diameter, but also upon flat surfaces or plates, in which case both surfaces receive the dust deposit. It is this latter type that has been installed at the Tooele plant of the International Smelting Co. for the recovery of the dust from the gases of the McDougall roasting furnaces. It consists of a flue having suspended plates forming the positive electrode and horizontal ¼-in. pipes for the negative electrode, the deposit of dust being chiefly upon the plate surface. This flue parallels and adjoins the main flue leading from a dust-chamber to the stack, and by means of dampers the gas-current can be turned into it. Fig. 1 is a cross-section of the flue, 10 ft. high, 12 ft. wide, and 64 ft. long, the top of steel plates, the sides of transite (asbestos) board in a steel frame. Suspended within and riveted to the tops are vertical plates made up of No. 20 corrugated iron, each plate 10 ft. long and 10 ft. high, its corrugations vertical, and the four sets aggregating 40 ft. in length, with a total of 64 plates spaced 9⅛ in. center to center. Midway between them are the rows of ¼-in. pipes, set 6 in. apart vertically, which act as do the wires or chains in pipe-treaters. The pipes, 26 ft. long, extend through two banks of plates, and to prevent them from sagging they are supported by three grids, one at each end and one in the middle between the two banks of plates. A grid is built up of 1¼-in. pipe drilled for the pipes to pass through, and suspended from a beam or busbar carried on the post insulators. The insulators and beams are boxed in, as are also the entering feed-wires and their bushings. Where the busbar passes through the box is an opening large enough to clear the bar by 2 in., the edge of the opening rounded by a ring so that the current shall not jump the gap. This is shown in Fig. 1.

Knocking devices are used to jar off the accumulated dust from the plates and the pipes. The plate-knocking device consists of a transverse shaft extending through the side walls, with a lever arm outside one wall to rotate the shaft, while inside are 16 spring-arms, one for each plate, each with its knocker. The pipe-knocking device consists also of a similar transverse shaft, each pipe-knocker jarring its corresponding middle grid-pipe by a vertically delivered blow. Vertical deflectors can shut off the flow at the inlet while the horizontal louvres adjoining can be regulated to create an even flow. "Sneak-baffles" are shown in Fig. 2,

intended to prevent any gas-current getting by plates and pipes. About every 2 hr. the electric current is shut off from the last plate-unit and this cleaned, the dust dropping into the hoppers below. The current is resumed and the next unit cleaned, and so in succession. The falling dust is so coherent that but little escapes to the stack.

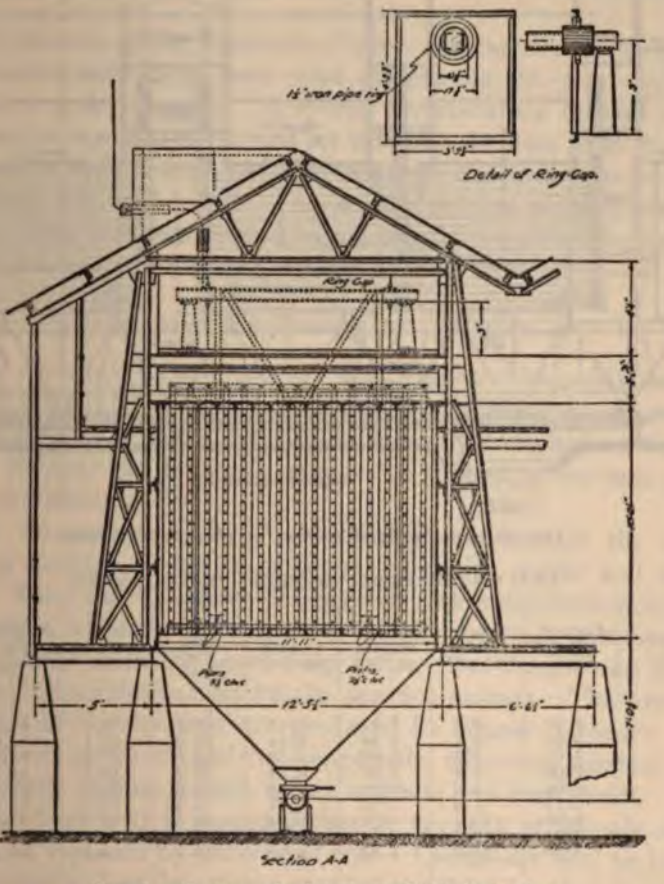


Fig. 1.—Section of plate-type Cottrell treater.

In supplying power the method followed is to step down one phase from the main power-line so that the current can be handled on the switchboard and put directly on the treater-transformer, using a synchronous motor to operate the rectifier. The voltage is regulated by means of a grid-resistor, the final adjustment being made by an induction regulator. The velocity of the gas-current will average 21 ft. per sec., or a brisk breeze of 15 miles per hr., so that it passes through the treater in 2 sec., in which

time an efficient selective precipitation is made, recovering 94 per cent. of the contained metals.

This distribution of the various components is shown in the following table, the hoppers being numbered from the intake toward the outlet.

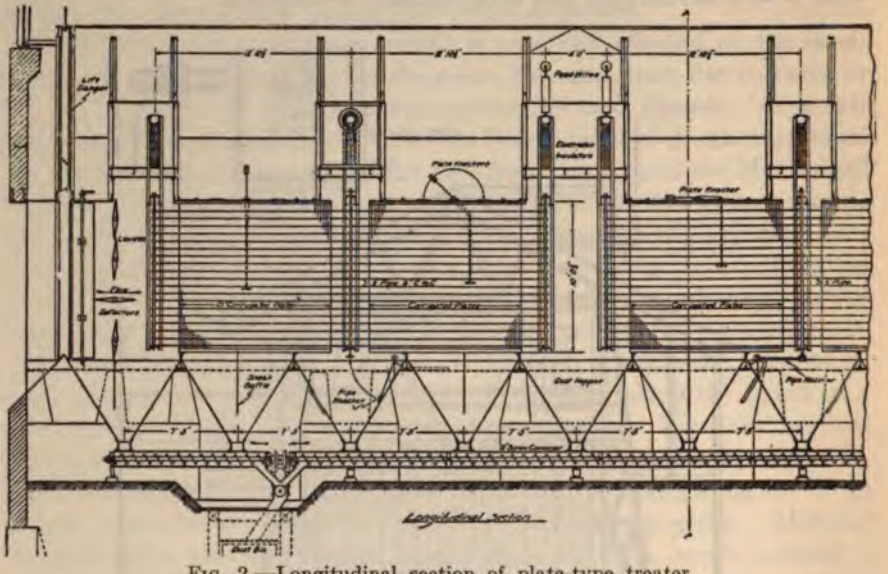


FIG. 2.—Longitudinal section of plate-type treater.

ANALYSIS OF DUST, COTTRELL PRECIPITATION

Hopper Number.	Copper, Per Cent.	Lead, Per Cent.	Silver, Ounces per Ton.	Gold, Ounces per Ton.	Insoluble, Per Cent.	Iron, Per Cent.	Sulphur, Per Cent.	Lime, Per Cent.
1	8.30	3.2	6.84	0.45	19.7	18.7	14.3	2.6
2	8.30	3.7	6.26	0.44	20.6	17.1	14.0	2.6
3	7.60	5.3	6.82	0.38	20.0	17.3	14.0	2.5
4	7.00	6.8	6.96	0.34	19.2	15.3	14.7	2.3
5	6.00	8.2	5.94	0.30	16.8	13.4	14.7	2.1
6	5.15	11.6	5.90	0.27	16.1	12.3	14.0	2.2
7	4.55	13.1	5.36	0.24	13.5	10.2	15.5	1.7
8	3.95	15.5	4.80	0.19	11.4	8.7	15.2	1.5
9	3.80	14.8	4.30	0.19	10.3	8.4	16.2	1.7

The constantly decreasing copper values and increasing lead values indicate that the true dust particles are precipitated first, then the impalpable lead fumes in larger proportion. The volume through the treater will average 146,000 cu. ft. per min., the temperature of the entering gases being 138° C. and at the outlet 127° C. The power consumed will average 8.4 kw. for the first electrical section, and 5.5 for the second. Some 85 per cent. of the dust that is caught is collected in the first section and 15 per cent. in the second.

It may be visualized that a dust-particle, borne by the rapid gas-current, wanders along until ionized, then jumps to the oppositely charged electrode.

Comparing this with the pipe system of collecting, it will be seen that we have a compact flue-like building capable of handling 50,000 cu. ft. of gas per min., as compared with a complex tall structure of equivalent capacity.

Cottrell Treaters of the Anaconda Copper Mining Co.[1]—The twenty Cottrell treater-units have been tried out during the year and have demonstrated their efficiency. A special reverberatory furnace with a Cottrell treater was also completed for smelting the dust from the main treaters, and a satisfactory recovery from the dust has been made of copper, silver, gold and arsenic. An arsenic refining plant of 400 tons monthly capacity has been created for refining the arsenical dust from the treaters of the special reverberatory.

Blast-furnace Smelting Plants and Methods

Sintered Flotation Concentrates for Blast-furnace Use.[2]—Without attempting to screen the product finer than 1-in. maximum size, success has resulted from sintering these concentrates as a preliminary to blast-furnace smelting. Sulphur can be partly retained as desired to conform to the furnace requirements.

Smelter By-products.[3]—E. P. Mathewson enumerates the varied by-products possible of use from copper reduction works and copper refineries. Thus the Tennessee Copper Co. makes sulphuric acid from the furnace gas, while some plants make liquid sulphur dioxide for which there is a market with the paper-pulp mills. The dioxide can also be used in making sulphuric acid by the contact process. The following metals and their compounds are produced by copper refineries: gold, silver, thallium, selenium and its compounds, tellurium, arsenic, platinum, palladium, iridium, nickel, nickel sulphate and blue vitriol.

Pulverized Coal.[4]—It is conceded that 30 per cent. of the coke on the charge can be replaced by pulverized coal. Commonly coal to be pulverized is dried to less than 1 per cent. of moisture, so that it will not cause trouble later in feeding. In one recent case in the southwestern United States, coal low in moisture has been ground and drawn to the furnaces by a suction-fan, and there blown into the furnace under pressure.

Use of Powdered Coal in Blast-furnaces.[5]—W. L. Wotherspoon describes a furnace at the Garfield smelter, Utah, where pulverized coal

[1] *Chem. Met. Eng.*, **23**, 136 (1920).
[2] *Eng. Min. Jour.*, **111**, 196 (1921).
[3] *Eng. Min. Jour.*, **111**, 196 (1921).
[4] *Eng. Min. Jour.*, **111**, 196 (1921).
[5] Mineral Industry, **28**, 193 (1919); *Eng. Min. Jour.*, **109**, 803 (1920).

replaces coke to the extent of 30 per cent. Such coal cannot altogether replace coke, since there must be reducing conditions within the charge, the coal being quite consumed at or near the tuyeres for the production of the heat needed for complete fusion of the charge and its ready flow from the furnace.

Fig. 3 shows the method of injecting the coal, fed from a coal supply above by a screw-feed to a branch pipe and so into a high-pressure air injection pipe within a tuyere of ordinary construction. It would appear that combustion cannot start until the mixed fuel and air is well within the charge.

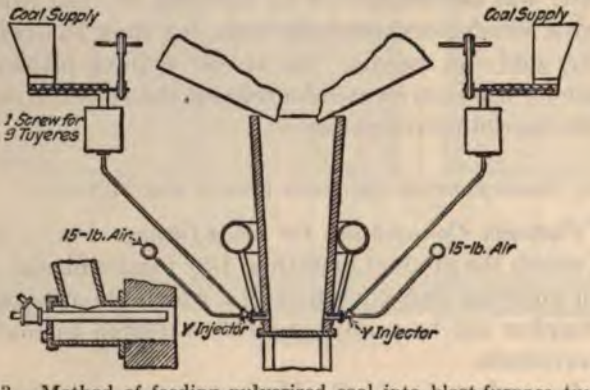


FIG. 3.—Method of feeding pulverized coal into blast-furnace tuyere.

Fig. 4 gives a vertical section of an improved tuyere where the pulverized coal is fed to the furnace by a branch pipe at the side. Falling into the annular space outside the regular tuyere it is swept forward by a separate air-blast to mingle with the low-pressure air. The tuyere nozzle is lined with refractory material which is kept quite hot by the igniting coal. An automatically closing ball-valve permits of punching the tuyere, while preventing the escape of air.

Use of Coal in the Matting Blast-furnace.[1]—H. C. Robinson tells of an attempt to make coke from a local coal, and this failing, the coal being used directly in the blast-furnace. The coal contained volatile combustible 19 per cent., fixed carbon 52, moisture 3, and a high ash of 26 per cent. Due to the scarcity of water and its hardness, the extreme cold (as low as minus 42° C. or minus 44° F.), the inferior labor, and the small percentage of sulphur in the charge (so that black copper would form in the settler), it was decided to make the furnaces of brick in place of having water-jackets as usual. The furnaces, erected in 1907, were of 19½ by 4-ft. hearth-dimensions, the tuyeres 18 in. above the hearth,

[1] *Min. Sci. Press*, **121**, 402, 409 (1920).

and the smelting column 11 ft. There are 16 tuyeres to the side, each 2¼ in. in diameter. The 12-in. bosh extends to the feed-door, and the hearth has a brasque tamped-in lining, which gives no trouble from corrosion, since it is always covered with metallic accretions when in operation. The furnace walls are of unburned silica (quartz) bricks, 12 in. thick. The mantel beams, 12 in. deep, are carried on pillars 10 ft. high, and the brick superstructure consists of a red brick wall faced with the same silica lining. The whole furnace is reinforced with cast-iron plates, and is bound with 6-in. I-beams. There are three charging-doors, all on one side. At each end of the furnace is a settler, 5 ft. long, 4½ ft. wide and 32 in. deep inside.

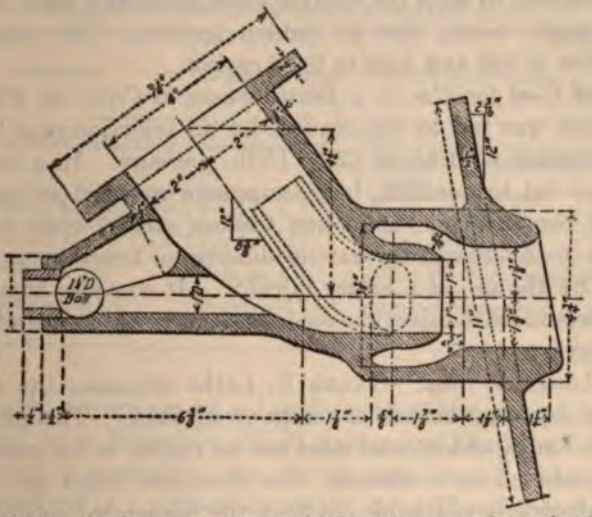


FIG. 4.—Design of safety vortex tuyere for blast-furnace using pulverized coal.

The ore (in 1917–1918) contained Cu 11.9 per cent., Fe 6.3, S 8.3, $BaSO_4$ 11.6, SiO_2 55.5 per cent., with silver 3.25 oz. and Au 0.01 oz. per ton. This was smelted with limestone containing CaO 49.3 and SiO_2 8.1 per cent., and with an iron ore of Fe 45.3 and SiO_2 13.8 per cent. to produce a matte of 55 per cent. copper and a slag of CuO .4 per cent., FeO 22.5, CaO 21.0, BaO 2.5, Al_2O_3 8, SiO_2 43.3 per cent. This means that a large proportion of iron ore must be added to the charge. Former persistent trials with little or no iron ore were unsuccessful, even with 36 per cent. of the coal fuel. With a similar charge the fuel consumption has been cut to 17 to 20 per cent., the tuyeres look dull, there are few irregularities. Under these conditions, and with a 24-oz. air-pressure, as much as 350 tons has been put through in a day. The furnace runs with a cold top, emitting the dense yellow fumes of unconsumed volatile

matter. The tendency of the walls to burn out is checked by feeding the charge to the walls, the coal to the middle. When the walls burn thin and repairs are needed, the furnace is stopped for a short time, and it is recommended that the wall be there broken through, the charge scraped out and the cavity packed with large balls of clay.[1]

After eight years of experience on blast-furnaces that use bituminous coal in the matte-smelting of copper ores, Mr. Robson believes that the top of the furnace should be made tight as in an iron furnace and the gases burned in waste-heat boilers, placing an automatic carbon-monoxide recorder beyond them, the extra air needed for complete combustion being supplied by a low-pressure fan having a variable-speed motor. Were it attempted to burn the volatile gases without a tight furnace-top, explosions might occur, due to sudden ignition. The most suitable coal is one low in ash and high in fixed carbon.

Pulverized Coal for Use in a Blast-furnace at Cerro De Pasco.[2]—The powdered coal was fed to the tuyeres by an injection-pipe inserted at the tuyere-branch with air at 12 to 15-lb. pressure. In a run of 50 hr. the coke was cut to one-half, being supplemented by the coal thus introduced at the tuyeres. Defective feeders caused some trouble, but this was to be overcome by having dust-proof bearings at the screw-feeder, and by the use of a better injector. It was also thought that a better way would be to inject the coal, preferably between and somewhat above the tuyeres.

Copper Losses in Slag.[3]—Frank E. Lathe discusses the methods of determining copper, whether as oxide or sulphide. The proportion of copper oxide varies widely, and need not be visible to the naked eye, but is rather combined as a silicate. On the other hand the chemically dissolved sulphide is negligible, so that the suspended sulphide may be regarded as being either of matte particles or a pure copper sulphide, left after oxidation of the accompanying iron sulphide.

The subjoined table shows the effect of variation in blast-furnace charges upon the copper content of the slags produced.

TABLE I.—BLAST-FURNACE SLAGS

Case No.	Per Cent., Copper.			Per Cent., Other Elements.			Temperature, °C.
	Oxide.	Sulphide.	Total.	SiO_2.	Fe.	CaO.	
1	0.12	0.07	0.19	47.1	13.3	22.2	1270
5	0.05	0.17	0.22	41.7	21.9	19.0	1225
6	0.07	0.14	0.21	40.1	24.3	18.8	1225
7	0.09	0.15	0.24	38.6	26.2	17.8	1225

[1] I have found it better to put in right-sized scrap-iron sheets, which, with two or three suitable iron bars, will hold back the charge until the cavity has been bricked up. It makes a better job. L. S. A.
[2] *Min. Sci. Press*, **121**, 55 (1920); MINERAL INDUSTRY, **28**, 194 (1918).
[3] *Eng. Min. Jour.*, **110**, 1076 (1920).

In case No. 1 the charge was a limy ore containing chalcopyrite and pyrite, but no oxidized copper. Case No. 5 was as No. 1, but with addition of 30 per cent. of 10 to 12-per cent. copper matte. The sulphur thus added favored the formation of but little copper oxide, but the slag, being heavier than in No. 1, the separation by settling was not so good. Cases No. 6 and 7 were like No. 5, but with addition also of 10 to 20 per cent. of converter slag. The copper oxide in the converter slag was but partially reduced, some going into the slag and raising the oxidized copper content in proportion to the converter slag added. In table II we give data regarding slags from well known smelting works;

TABLE II.—COPPER IN BLAST-FURNACE SLAGS

Sample.	Company.	Plant Location.	Nature of the Charge.	Copper, Per Cent.	
				Total.	Oxide.
1	British America Nickel Corp.	Nickelton, Ont.	Heavy sulphide ore containing both nickel and copper	0.05	0.015
2	Cananea Cons. Copper Co.	Cananea, Mex.	Little oxidized copper	0.33	0.055
3	Cons. Mining & Smelting Co.	Trail, B. C.	Heavy sulphide ore	0.255	0.030
4	Granby Cons. M. S. & P. Co.	Anyox, B. C.	Heavy sulphide ore	0.145	0.025
5	Granby Cons. M. S. & P. Co.	Anyox, B. C.	Matte concentration	0.295	0.015
6	Old Dominion Copper Co.	Globe, Ariz.	Some oxidized copper	0.360	0.250
7	Phelps-Dodge Corp.	Douglas, Ariz.	About 1 per cent. copper in oxidized condition	0.420	0.340
8	Tennessee Copper Co.	Ducktown, Tenn.	Heavy sulphide ore	0.220	0.020
9	Tennessee Copper Co.	Ducktown, Tenn.	Matte concentration	0.440	0.150

With a high percentage of sulphur on the charge, and no oxidized copper present, as at Nickelton, Trail, Anyox and Ducktown, the copper oxide in the slag is negligible; but, on the other hand, when partly oxidized ore is smelted to a high-grade matte, as at Douglas and Globe, the conditions are not sufficiently reducing to remove the copper oxide, though the low percentage of sulphide copper indicates efficient settling. Matte concentration at Ducktown resulted in increased amount of copper oxide in the slag, but did not do so at Anyox, where the conditions were less oxidizing. Table III gives data on reverberatory slags as follows:

TABLE III.—COPPER IN REVERBERATORY SLAGS

Sample.	Company.	Location of Plant.	Remarks.	Copper, Per Cent.	
				Total.	Oxidized.
10	Anaconda Copper Mining Co.	Anaconda, Mont.	.....	0.35	0.24
11	Anaconda Copper Mining Co.	Anaconda, Mont.	.....	0.37	0.30
12	Anaconda Copper Mining Co.	Anaconda, Mont.	Converter slag furnace	0.60	0.24
13	Cananea Cons. Copper Co.	Cananea, Mex.	Low-grade matte produced	0.145	0.07
14	Phelps-Dodge Corp.	Douglas, Ariz.	.....	0.29	0.24

The Anaconda and Phelps-Dodge slags indicate that three-fourths of the copper is present as oxide. At Cananea the low copper, both total and as oxide, is due to the low-grade (15 to 20-per cent.) matte treated. As regards the converter slag treated at Anaconda the results are peculiar. Though the total copper is higher than in regular reverberatory smelting, the oxidized copper is not, showing that this latter was reduced, due to the addition of low-grade sulphide ore to the furnace. On the other hand it is probable that the buoying up of sulphide particles by enveloping gas, in presence of magnetite, is responsible for considerable loss.

As shown in Table IV there is a wide variation in converter slags of oxidized copper, this being low in presence of much iron (or nickel), which oxidizes in preference to copper, so that the converter slags of a plant treating low-grade matte will be low compared with those treating matte of high tenor in copper.

TABLE IV.—COPPER IN CONVERTER SLAGS

Sample.	Company.	Plant Location.	Remarks.	Copper, Per Cent.	
				Total.	Oxidized.
15	Anaconda Copper Mining Co.	Anaconda, Mont.	.....	4.88	3.85
16	British America Nickel Corp.	Nickelton, Ont.	Beginning of blow, nickel present	1.23	0.06
19	Cananea Copper Co.	Cananea, Mex.	.....	1.54	0.56
20	Cons. M. & S. Co.	Trail, B. C.	.....	1.97	0.88
21	Granby Cons. M. S. & P. Co.	Anyox, B. C.	.....	2.56	1.04
22	Old Dominion Copper Co.	Globe, Ariz.	.....	3.61	2.40
23	Phelps-Dodge Corp.	Douglas, Ariz.	.....	3.53	2.21
24	Tennessee Copper Co.....	Ducktown, Tenn.	.....	1.00	0.77

The efficiency of cleaning converter slag by pouring it into the forehearth or settler of a blast-furnace is an unsettled question, but it appears that it pays to do it. As such slag falls through the bath of lighter blast-furnace slag, it must settle to the surface of the underlying matte, where reduction should take place. Such heavy slag only gradually finds its way out of the settler and its influence is felt over a considerable interval of time.

The Mond Nickel Co. gives the following figures of slag composition in pouring converter slag into its settlers:

	Cu, Per Cent.	Ni, Per Cent.	Fe, Per Cent.
Blast-furnace slag.....	0.17	0.22	26.6
Converter slag.....	0.70	1.30	45.4
Resultant settler-slag	0.20	0.29	29.9

By calculation, taking the respective weights of the slags thus mixed, 51.4 per cent. of the copper has been recovered as the result of this treatment. Mr. Lathe thinks the more pronounced settling should be done

by the use of a large forehearth followed by smaller ones in series, and that some coarse pyrite should be added to the next to the last. In this way the sulphur, driven from the pyrite by the heat, stirs up the slag and reduces oxidized copper; also some low-grade matte is yielded, which tends to take up dissolved sulphides.

Due to the neutral atmosphere of the reverberatory, the loss of copper as oxide is likely to be high. The use of a submerged dam across the furnace near the front is proposed. There is created a pool where the slag can be cleaned by addition of pyrite. From this pool the resultant low-grade matte can be tapped off, while the regular matte in the main body of the furnace is separately withdrawn.

Copper and Magnetite in Slags.[1]—Chas. G. Maier and G. D. Van Arsdale give the results and conclusions derived from the examination of a series of representative slags, showing how copper losses occur, the relation of magnetite to copper loss, the behavior of converter slags in reverberatory furnaces, and suggestions for reducing losses of copper in such slags. This should be read in connection with Mr. Lathe's discussion on the same subject, above given.

Maier and Van Arsdale state that in these slags the copper occurs often about half as sulphide inclusions or pellets, mechanically retained, and the rest in solution as sulphide, and so not microscopically visible, as shown in the subjoined table No. V. The pellets, as the result of chemical reactions, evolve sulphur dioxide, and lose iron as magnetite, rarely with the appearance of minute globules of metallic copper. When the converter slag is added in the reverberatory there is a connection

TABLE V.—COMPARISONS OF CHEMICAL ANALYSES AND COPPER CONTENTS OF TYPICAL SLAGS

No.	Slag.	Per Cent. Cu.	Per Cent. Dissolved Cu.	Per Cent. Pellet Cu.	Per Cent. SiO_2.	Per Cent. Al_2O_3.	Per Cent. CaO.	Per Cent. CaO + MgO.	Per Cent. S.	Per Cent. FeO.
1	Copper Queen blast-furnace	0.35	0.16	0.19	36.0*	11.0*	.....	7.0*	.....	38.0*
2	Copper Queen reverberatory	0.28	0.22	0.06	40.76	11.43	4.88	7.61	0.41	37.56
3	Morenci blast-furnace.....	0.30	0.15	0.15	35.0*	10.0*	.....	18.0*	.....	34.0*
4	Old Dominion blast-furnace	0.36	0.13	0.23	37.0*	9.0*	.....	16.0*	.....	34.0*
5	United Verde Extension....	0.34	0.19	0.15	43.86	5.55	12.81	13.53	0.37	34.32
6	Arizona Copper Co., No. 1.	0.37	0.21	0.16	39.98	11.70	3.46	5.89	0.52	39.30
7	Arizona Copper Co., No. 2.	0.40	0.20	0.20	38.80	11.38	3.07	5.31	0.40	42.35
8	Arizona Copper Co., No. 3.	0.40	0.25	0.15	41.35	11.45	6.14	8.65	0.29	34.81
9	Arizona Copper Co., No. 4.	0.32	0.24	0.08	41.69	11.71	6.03	8.33	0.25	36.36
10	Calumet and Arizona.....	0.23	0.18	0.05	42.70	6.56	6.52	8.19	0.73	39.96
11	El Paso, No. 1.....	0.46	0.25	0.21	41.04	5.88	5.68	7.39	0.40	42.87
12	El Paso, No. 2.....	0.38	0.25	0.13	41.75	6.44	5.16	6.41	0.58	44.31
13	A. S. & R., Hayden.....	0.34	0.11	0.23	37.22	6.78	15.02	16.63	0.47	38.27

* Estimated approximate average.

between the ferric iron (magnetite) and the copper loss as pellets or inclusions, and the amount of this loss is proportional to the oxidizing strength

[1] *Chem. Met. Eng.*, **22**, 1101, 1157 (1920).

of the slag in its magnetite content. The dissolved copper sulphide is unaffected.

As shown by the table the pellet copper varies according to the efficiency in settling, while the dissolved copper remains pretty constant. And so we may say that of the total copper present in reverberatory slag, a part, usually less than half, and averaging 0.45 per cent., consists of prills or pellets of sulphide, whereas the remaining copper is in dissolved form as sulphide, and averages 0.20 per cent.

The microscopic examination of copper mattes indicates a two-phase structure consisting of an iron sulphide and of a copper sulphide, while smelter slags show pellets like white metal. It is the sulphur-dioxide gas-bubbles, attached to many of these pellets, that tend to increase their loss, as settling is less efficient. In converter slags the copper is largely present as white-metal pellets or inclusions.

Let us now consider the operation of reverberatory smelting in connection with copper losses: The roasted calcine charge may be considered as being partly copper oxide, so that in a typical example, out of 10 per cent. copper in the cooled ore, 3 to 4 per cent. was soluble in acid. However, the copper not held by the slag is finally found in the matte, since the reaction $FeS + Cu_2O = Cu_2S + FeO$ takes place during the melting down of the charge. At this time the forming slag takes up copper sulphide, while entrained sulphide globules float in it throughout. Some of the iron oxide present oxidizes to magnetite, while the matte, during the melting, sinks to the matte layer beneath, there reacting with the magnetite, and setting free sulphur dioxide. As far as the copper loss is concerned we may conclude that the slag takes up its maximum of dissolved sulphide, and contains entrained sulphide globules. The matte, protected by the slag above it, does not oxidize as can the exposed slag where the ferrous iron is oxidized to magnetite. As soon as the magnetite crystals attain appreciable size they settle through the slag to the matte layer beneath. The sulphur-dioxide gas set free rises, producing the "boil," and carries with it the sulphide globules, constituting the second loss in the slag.

Referring now to Fig. 5, we see that when the charge is heated, the first equivalent of sulphur in the iron pyrite is driven off. Taking the history of the reverberatory charge, represented by all above the horizontal center line, there occurs the change of physical state, *A*. This, a process of melting, involves a separation during fusion, into slag saturated to the extent of perhaps 0.15 to 0.20 per cent. with copper as sulphide (carrying entrained copper sulphide), and into matte which settles from the supernatant slag.

In stage *B*, "the approach of chemical equilibrium," magnetite forms,

and this reacting with the matte according to the equation $2CuS + 2Fe_3O_4 = Cu_2S + 3Fe_2O_3 + SO_2$, results in an evolution of SO_2 gas.

In the third stage *C* marked "chemical equilibrium balanced by physical," sulphide globules, entrained by the rising sulphur-dioxide gas, increase in number, and the ferric iron is changed to ferrous form.

Finally, in the fourth stage, *D*, marked "mechanical separation," the matte has improved in grade, due to the escape of sulphur dioxide, and the slag appears carrying its dissolved sulphide and globules.

In the treatment of converter slag, poured into the reverberatory furnace in molten form and already possessing magnetite, this reaction causes increased elimination and suspension of sulphur dioxide, and as a result the slag is not so clean, but as before, the grade of the matte is increased.

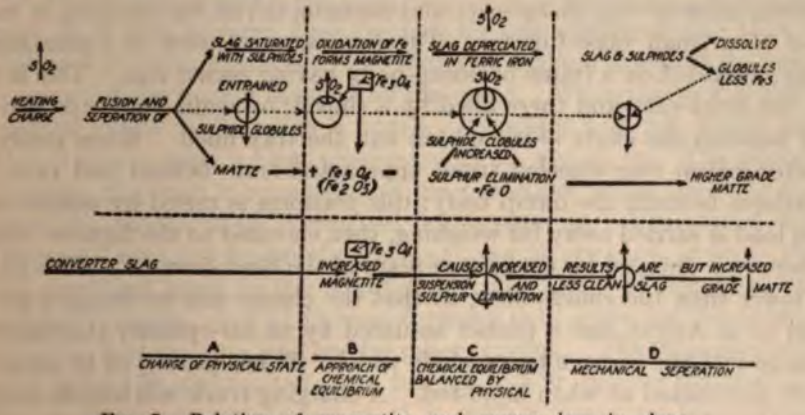


FIG. 5.—Relation of magnetite and copper loss in slags.

The writers hold out little hope of a closer saving of copper through changing the charge or by varying the temperature; they feel that there is more to be gained by attempting to save suspended copper sulphide globules, and this as the result of proper non-oxidizing smelting, true also in the treatment of converter slags. However, it is fortunate that there is always some reduction going on at some point in the reverberatory, though the main effect is one of oxidation. Therefore, if converter slag has to be added, then a reducing zone should be maintained somewhere in the furnace.

Better yet is it, as at Anaconda, to add to the molten converter-charge sufficient pyritic silicious material to produce a low-grade matte in order effectively to reduce the magnetite.

Matte and Slag Separation in the Forehearth.[1]—R. L. Lloyd has patented a device consisting of a refractory brick well in the forehearth,

[1] *Eng. Min. Jour.*, **109**, 806 (1920); U. S. Pat. No. 1,310,998, July 22, 1919.

where the furnace-flow will drop into it, the well having openings near the bottom for the out-flow of the mixed slag and matte. As the mixed flow rises through the molten bath of the forehearth the prills of matte join the matte-bath while the slag rises to the out-flow launder. Another way is to build a wall of refractory brick across one end of the settler with similar outlet, a device already long in use.

Improved System of Dumping.[1]—In the older way the train of slag pots was spotted and each pot at once dumped. This resulted in an overhanging dump, liable to give way unexpectedly. The present practice is to move the train so that all the pots are dumped at one point. This gives an abundant flow, and the slag spreads out so that the slope of the dump is flattened.

Charging Apparatus for Small Blast-furnaces.[2]—A. W. Carroll describes labor-saving charge-cars and charging device for charging at each end of a small blast-furnace. The apparatus consists of a side-dump tray, mounted on a frame or dump-body having corner legs. This is set at the stock-pile, and there filled by a shovel; or again the frame can be set beneath the chute of a feed-bin and the tray filled. When ready, a motor-driven four-wheeled truck approaches from behind and runs its platform beneath the dump body; this platform is raised by motor, and the load is carried away for weighing, then elevated to the furnace floor, where it is dumped on the charge-plate of the blast-furnace. This plate is lower than the charge-floor, so that the charge can be dumped on it, and as at Anyox, has a pusher actuated by an air-cylinder shoving the charge into the furnace to its whole width. It has proved to be quite as well distributed as when hand-fed. A charging truck will handle nearly 150 tons daily.

Blister Copper Smelting at Rio Tinto.[3]—The smelting works comprise five water-jacketed blast-furnaces of 250 tons daily capacity each; the ore is smelted using but 1.6 per cent. of Welsh anthracite for fuel. The furnaces yield a 20-per cent. copper matte, which is sent directly to the converters.

Due to the low grade of the matte, converting is prolonged, resulting in greater wear and tear and increased labor. The plant produces annually 15,000 to 20,000 tons of blister copper.

The Hidachi Smeltery, Hidachimua, Japan.[4]—This works is noted for having the highest concrete stack in the world. The stack rises 550 ft. from the foundation on top of a hill 200 ft. above the works, and 1220 ft. above the level of the sea, 3 or 4 miles away. This great height has been given it to insure freedom from damage to agriculture. The charge smelted consists of about 70 per cent. Hidachi cupriferous pyrite of 3

[1] *Eng. Min. Jour.*, **109**, 1109 (1920).
[2] *Min. & Met.*, Dec., 1920.
[3] *Min. Sci. Press*, **122**, 185 (1921).
[4] *Eng. Min. Jour.*, **111**, 55 (1921).

per cent. copper and 18 to 24 per cent. silica with 30 per cent. of custom ore, one-third of this being silicious with 3 per cent. copper, and two-thirds gold- and silver-bearing quartz having 0.1 per cent. copper and 85 per cent. silica, this latter being used as converter flux. All the ores, when screened over a ¾-mesh screen, yield about 40 per cent. fines. The green-ore fines and the blast-furnace flue-dust are sintered together in cast-iron tapered pots 12 ft. in diameter by 4 ft. deep, having grated bottoms, and of 16 tons capacity. A pot stands on a ring set 4 ft. below floor-level, which makes a joint with the pot all round, the blast-air being admitted within the ring. The annular space outside the ring connects by flue to the stack. The pots and their hoods are handled by a 30-ton overhead traveling crane.

In operation rough straw mats are spread over the grate and set afire. A truncated conical sheet-iron hood, having both inspection and charging doors, is at once lowered over the pot, its base slightly larger than the annular flue above mentioned. A charge of ore and flue-dust is dumped in, using a 5-ton bucket handled by the crane. When this is well ignited a second and a third charge is added. To sinter a 15-ton charge takes about 5 hours, using a blast-pressure of 15 oz. per sq. in. The sintering complete, the hood is removed and the pot taken to the breaking floor, where the sintered mass is dumped and broken up. The broken sinter is screened over a 1-in. grizzly that removes 20 per cent. of fines, these fines reverting again to the sinter-pots. The coarse is sent to the first matting furnaces. Out of 10 blast-furnaces only seven are in operation, six for the first matting, and one for concentrating. The tonnage smelted varies from 170 tons for the 15-ft. furnace to 250 tons for the 24-ft. one. The ore column is maintained at 11 ft. with a maximum blast-pressure of 20 oz. per sq. in. The first furnaces yield a 20-per cent. matte, which is concentrated in the matting furnace to 35 per cent. copper. The respective slags run 0.2 and 0.4 per cent. copper. Water-cooled fore-hearths of 15 to 20 tons capacity are used, and the matte is tapped into pans of an endless-chain casting machine. The first-matte furnaces are side-charged by hand, the concentrating furnace by bottom-dump cars running above it, the smoke being carried off below the floor by side flues. The flue-dust is 2.7 per cent. of the ore charged. The blast-furnaces use 7.5 per cent. fuel, one-third coke and two-thirds bituminous coal; the coke is fed with the charge, while the coal, crushed to 1-in. size, is charged through the tuyeres by hand-operated plungers working in small cylinders introduced through the tuyere-caps, and feeding about 7 lb. of coal at a time. The method is wasteful of labor, and it is proposed to supersede it by the use of pulverized coal. The slag, granulated with water, is sent to the dump in electrically operated cars.

The six stands of converters are of the barrel type, 68 in. in diameter by 8 ft. long, are acid-lined, and take the matte from small ladle-cars into which the matte from the concentrating furnace is tapped. Each converter has eleven 1¼-in. tuyeres taking air at 8 lb. pressure from a turbo-blower. The converter slag, carrying 2.5 per cent. copper, is sent to the first matting furnaces.

The blister copper is cast in ingots of 400 lb. from a swinging launder to stationary copper moulds, arranged in a semi-circle and cooled by water-jets underneath.

The United Verde Smeltery, Clarkdale, Ariz.[1]—The plans for enlargement of this works, as described in MINERAL INDUSTRY, **28**, 207 (1919) call for a plant of 12,000,000 to 15,000,000 lb. of copper monthly, much of the ore to be treated to come from steam-shovel work in the fire-zones of the mine. The plan of the operations will consist in removing the old buildings from the old slag-dump, and the overburden from over the fire stopes down to the 500-ft. level by means of steam-shovels, and forming at that level an extensive flat for a new townsite. The three shovels now in operation are of 8 cu. yd. capacity. To expose the estimated 5,000,000 tons of ore it will be necessary to strip some 14,000,000 tons of overburden. The increased equipment, involving the use of more waste-heat boilers, will bring up the total horsepower from this source to 8400. The increased ore tonnage will call for a new crushing plant at the smelter, superseding the present one at the Hopewell tunnel at the mines. The ore will be stored in stock-piles, to be picked up as needed by gantry cranes, the storage capacity being 250,000 tons.

The classes of ore, as shipped to the smelter in 1918, may be thus described:

"Oxide Ore." A small tonnage of this ore from the oxidized zone above the 160-ft. level, and containing Cu 2.6 per cent. and SO_2 34.1 per cent., is smelted directly.

"Iron Ore." This comes from the massive sulphide stopes, and contains Cu 6.1 per cent., Fe 31.6, SiO_2 8.8, S 34.9 per cent.

"Silica Ore." The ore from the black schist and porphyry stopes, and containing more than 15 per cent. silica, is thus classed, though it often contains much iron, while much of the silica occurs combined with alumina. It contains Cu 5.0 per cent., Fe 24.1, SiO_2 19.3, Al_2O_3 10.4, S 19.4 per cent. (The two kinds, just named, the iron and the silica ore, constitute the bulk of the ore smelted. They contain 2.0 oz. silver and 0.025 oz. gold per ton).

"Converter Ore." This is mined in the quartz porphyry, and is used as flux at the converters and for fettling the reverberatories. It contains but 2.1 per cent. copper, but is high in silica (67 per cent.).

The ore is crushed at present at the Hopewell plant, pending the construction of a new crushing plant at the smelter. It is broken in a No. 9

[1] *Min. Sci. Press*, **121**, 547 (1920); MINERAL INDUSTRY, **26**, 182 (1917); **28**, 207 (1919); private notes.

gyratory crusher to 4 or 5-in. size, and screened over 1½-in. square holes. The oversize is fed direct to the blast-furnaces, the undersize is further crushed at the smelter. This crushing is done by one of two 48-in. vertical Symons disc crushers (the second disc crusher being kept in reserve), through four 54 by 24-in. rolls to pass a 7/16-in. round hole, and thence goes to the roasters. Though too coarse for the best roasting, this is all that can be done with the present equipment.

The total capacity of the storage bins is 28,000 tons. From the coarse bins the ore is discharged through weighing-hoppers of 3 tons capacity into charge-cars and thence to the blast-furnaces. The ore from the fine ore-bins is withdrawn through calibrated gates upon 30-in. belt-conveyors, the regulation of the gates being such as to secure the proper proportions of the several ores. The belt-conveyor delivers upon an inclined belt-elevator, and thence into the roaster-hoppers, these being filled upon the day shift.

The twelve roasters that are to be added to the present equipment are of the Wedge type, 22½ ft. in diameter, having one drying and seven roasting hearths, and driven by a 35-hp. motor. The furnace-shaft is upon roller-bearings running in oil. The roaster fume is caught in a dust-chamber 50 ft. wide, 21 ft. high and 140 ft. long, connected to a central steel stack, 30 ft. in diameter by 400 ft. high, lined with brick. A 20-ft. section in the middle of the dust-chamber was hung with wires at 3-in. centers. These had been superseded by the Frisbee type of the Cottrell process. In this the wires were arranged in two groups, one group being active high-voltage wires, the other having the wires grounded. Success did not result, so plates were hung between the groups of wires, and on these the flue-dust was deposited; but neither was this satisfactory. Due to lack of roaster capacity even on present production, the roasters have been crowded, so that 93.2 tons have been put through a roaster of 75 tons capacity, and 1724 bbl. of oil was used monthly for twelve roasters, or 4.7 bbl. per furnace-day. With the twelve large additional Wedge roasters in operation, fuel-economy will result.

The statistics on roaster operation for January, 1920, are as follows:

	Tons Charged.	Copper, Per Cent.
Converter ore	4,400	1.51
Silica ore	13,963	5.26
Iron ore	15,906	6.05
Total	34,269	5.15
Calcine recovered		28,649
Shrinkage, tons		5,620
Shrinkage, per cent.		16.40
Furnace-days		367.56
Tons of charge per furnace-day		93.2

The Reverberatory-furnace Plant.—The calcine is hauled to the reverberatories in 22-ton cars by 10-ton electric locomotives. The present

plant consists of three furnaces, 19½ by 100 ft., and oil-fired. They are rated at a daily capacity of 650 tons of solid charge plus 120 tons of liquid converter slag per furnace. The three new furnaces are 25 by 100 ft. All are lined with silica brick except at the tap-holes, where chrome brick is used. The roofs are transversely ribbed as at Anaconda. The older three furnaces will last to 100,000 tons before re-lining; the new ones are expected to last to 150,000 tons, because of their greater width.

To avoid the use of long launders, a tunnel is provided between each pair of furnaces, so that the matte may be tapped directly at the flue-end into a ladle carried on a small trunk in the tunnel. The truck is transferred to the converter building and the ladle, of 200 cu. ft. capacity, picked up by crane and poured into the converters. The slag from the reverberatories is hauled to the dump in 225-cu. ft., electrically tilted slag-pots, using an 18-ton locomotive. The gases from each furnace pass through two 700-hp. Stirling boilers, making six in present use, with six more to be added with the new furnaces. Besides these there are two oil-fired boilers of the same capacity for furnishing extra steam.

The statistics on reverberatory operation for January are as follows:

	Tons.	Copper, Per Cent.
Silicious ore (fettling)	504	1.51
Calcine	28,649	6.40
Blast-furnace flue-dust	1,338	14.80
Roaster-dust	1,577	6.30
Total	32,068	6.67
Furnace-days		62
Tons per furnace-day		517

In addition to the ore-tonnage, approximately 120 tons of liquid converter slag is charged per day.

	Bbl.	Bbl. Per Ton of Solid Charge.
Fuel-oil	19,484	0.61
Credit of waste-heat	6,819	0.21
Balance charged to reverberatories	12,665	0.40

The matte ranges from 27 to 30 per cent. copper, and the slag averages 0.38 per cent. copper and 36 per cent. silica.

The Blast-furnace Plant.—There are four blast-furnaces, each 48 in. wide by 26 ft. long hearth dimensions, with 48 tuyeres 4¾ in. in diameter. They have the Giroux hot-blast tops. The blast is heated to 40° C. to 65° C. The exact advantage of this has not been determined, but long experience seems to justify it. The blast-furnace gases are carried through a dust-chamber 220 ft. long by 59 ft. wide by 29½ ft. high to the blast-furnace stack. The matte is tapped directly into 200-cu. ft. ladles in the converter aisle, while the slag is removed in 225-cu. ft. slag-pots to the dump. The blast-pressure varies from 22 oz. to 40 oz., depending on the capacity desired.

The statistics for blast-furnace operation in January are as follows:

	Tons.	Copper, Per Cent.
Silica ore	12,932	5.26
Iron ore	18,530	6.05
Converter ore	41	1.51
Oxide ore	2,472	0.73
Swansea lease	562	22.86
Total ore	34,537	5.64
Limestone	5,862	.....
Smelter cleanings	4,988	.....
Total charge without coke	45,387	5.39
Furnace-days		61.8
Tons per furnace-day		734
Tons per square foot of hearth-area		7.06
Coke, per cent.		6.1

The matte averages 25 per cent. in copper and the slag 0.4 per cent.

In March the best results were attained when the output was 734 tons per furnace-day, using 5.85 per cent. of coke to the charge. There was 5.87 per cent. copper in the charge and 25.7 per cent. in the matte, or a concentration of 4.4 into 1. Some runs have been made for a short time with 4.5 per cent. of coke.

The Converter Plant.—There are six 12-ft. basic-lined converters of the Great Falls type, of which five have been in operation. Two more stands have been added. The lining is magnesite brick 15 in. thick; the tuyeres are 16 in number, 1½ in. in diameter, and containing an inner pipe that can easily be replaced. The air-pressure averages 14 lb. per sq. in. A converter is turned by a 50-hp. electric motor acting through a steel worm upon a shrouded brass worm-gear fitted upon its spider. When the shrouding wears out it may be replaced. As already mentioned, the matte from both reverberatories and blast-furnaces is transferred to the converters by means of 200-cu. ft. ladles. Flux is spouted into the converter in quantity as desired from overhead bins, the latter kept supplied by a belt-conveyor. The matte is blown to blister of 99.4 per cent. copper, carried in ladles to one of the two straight-line casting machines, there cast into 400-lb. ingots, and shipped to an Eastern copper refinery.

Pulverized Coal Plant.—This is under construction to replace oil-firing at the reverberatory furnaces. For these the coal is stored under water in two concrete open-top bins, holding together 15,000 tons.

The coal from the cars and from the storage to the feed-bins is handled by means of a gantry crane operating a 2½-yd. clam-shell bucket. The feed-bins deliver to a belt-conveyor 36 in. wide, that, at the end of the bins, rises at an angle of 15°, dropping the coal into a primary breaker driven by a 50-hp. motor. From this breaker the coal falls upon another belt-conveyor which takes it to the dryer building, equipped with two Ruggles-Coles A-14 coal-dryers, each driven by a 200-hp. motor. Space is provided for a third dryer. From the dryer building, the coal passes

to two Jeffries coal-disintegrators, thence by bucket-elevators to feed-bins in the pulverizer building, where space has been left for a third disintegrator. From these feed-bins the crushed coal drops to eight 5-roller Raymond impact pulverizing mills. The blowers of these mills maintain a suction of 16 oz. per sq. in. at the top of each mill, which progressively carries off the finely-ground portion, leaving the particles for re-grinding. From the mills, the suction-fan carries the powdered coal to a 16-in. screw-conveyor, by which it is delivered into 60-ton bins, one in front of each reverberatory furnace. Firing will be done through five burners to each furnace. To avoid fire and explosions, the buildings are of brick and concrete on a steel frame, and have large windows and good ventilation, and ample space is provided for all the machinery. Also the conveyors and other apparatus can be easily hosed off with water. As a result of these precautions the plant has proved itself to be remarkably free from dust.

The Cottrell Treater-plant.—Plans have been made for a plant having fifteen sections of pipe-treaters, three sections of plate-treaters as at Tooele (elsewhere described), and with space provided for future expansion by twelve more sections. This plant is to take the gases from blast-furnaces, the reverberatories and the converters by flues to the delivery flue at the treater-plant. The exit-flue leads to a single stack.

Costs at the United Verde Smelter.[1]—The plant, at the time estimates of cost were given, was not running at capacity and was producing 7,000,000 lb. per month from 74,000 tons of ore. In spite of excessive and varying conditions increasing costs, the operations are well and economically carried out, and the figures below given compare favorably with those of other smelters. The blast-furnaces, smelting 8.5 tons of charge per sq. ft. of hearth area, are producing from an ore of 5.87 per cent. copper a 25.7-per cent. matte, with a consumption of 5.85 per cent. of coke per ton of charge. Costs for January, 1920, were:

Per ton of charge for blast-furnace operation	$1.84
Per ton of ore	2.42
Per ton of calcine for reverberatory (with deductions)	1.51
Per ton of calcine roasted in Wedge furnaces	0.25
Per ton of calcine roasted and smelted	1.76
Per ton of blister copper produced at the converters	12.00

The recovery was 88.54 per cent., much of it being flue-dust loss. The roasting cost is:

For belt-conveyors	$0.03
Fuel-oil (the roasters being crowded)	0.12
Labor	0.07
Unclassified expense	0.01
Total calcining cost per ton of charge	$0.23
Total calcining cost per ton of calcines produced	0.25

[1] *Min. Sci. Press*, **121**, 547 (1920).

The net reverberatory smelting cost is as follows:

Tramming and weighing		$0.09
Fuel-oil		1.54
Labor		0.39
Slag removal		0.07
Unclassified expense		0.04
		$2.13
Less credit for steam produced by waste-heat boilers	$0.54	
Less credit for smelting blast-furnace flue-dust	0.08	0.62
Net cost for reverberatory smelting, per ton of calcine		$1.51

This makes the net cost for roasting and reverberatory smelting $1.76 per ton of calcine. Fuel-oil costs $2.53 per barrel, f.o.b. at the smelter. All the reverberatory furnaces are being equipped for the use of pulverized coal.

Blast-furnace smelting costs are:

Tramming and weighing the charges	$0.09
Coke ($15.32 per ton at smelter)	0.93
Blast air	0.24
Labor	0.30
Limestone flux	0.10
Removal of slag	0.07
Unclassified expense	0.05
Reverberatory charge for treating flue-dust	0.06
Net cost per ton of blast-furnace charge	$1.84
Net cost per ton of ore charged (76 per cent.)	2.42

It will thus be seen that the blast-furnace expense per ton of ore ($2.42) is greater than roasting and reverberatory treatment ($1.76) at a time, too, when fuel-oil is used. Change to the use of pulverized coal, as already arranged for, will further reduce reverberatory costs. We may expect slag losses to be less in the reverberatory, since there is no addition of fluxes, as in the blast-furnace.

Reverberatory Smelting Plants and Methods

The Martin Sampling Machines for Sticky Concentrates.[1]—This machine was developed for the handling and sampling of flotation concentrates of 15 to 25 per cent. moisture, formerly removed from the railroad cars by shoveling. This cost as much as 20 cts. per ton, and was a distasteful operation for the shovelers, causing strikes, and resultant congestion of the cars in the yards.

In the Martin machine the concentrates, in flat-bottom railroad cars of 75 tons each, is brought on tracks on either side of the platform, on which the unloader operates. The entire machine is mounted on a traveling gantry which is moved along by an electric motor as unloading proceeds, in fact the gantry is so long that a train of five cars can be unloaded without switching. The actual unloading is done by a 1½-ton clam-shell bucket, so arranged that it can dig in cars on either side of the

[1] *Min. Sci. Press*, **122**, 17 (1921); private notes.

gantry track, the load being then received into a central hopper at the top of the machine. The bucket empties the car cleanly. The 20-ton receiving hopper has a grating of steel I-beams spaced at 3-ft. centers. The bottom of the hopper, 9 ft. square, consists of a 9-ft. 6-ply belt, traveling with an endless conveyor composed of wooden slats, 2 by 4 in., re-inforced on the under side by 4-in. steel channels, the slats carried on roller chains. The 9-ft. belt has one transverse joint spliced with belt rivets, so that it can be removed if necessary. The movement of the belt forces a continuous layer of the muddy concentrate through the horizontal space, 6 in. high across the 9 ft. width of the hopper. Parallel to the discharge pulley-shaft is the shaft carrying the "chopper," a series of eleven 11-in. diameter discs that slit the layer of concentrates into ribbons. Also, twelve wires of No. 12 steel parallel to the chopper-shaft, and strung through the edges of the discs, chop the ribbons transversely, so that we get squares of concentrate 4-in. thick. Revolving below the chopped stream composed of these squares, its axis parallel to the chopper shaft, is a hollow cylindrical drum 30 in. in diameter by 9 ft. long, having a longitudinal slit. When this slit, 16-in. wide, opens upward it takes the falling material, but nine-tenths of the time the flow is upon the surface of the drum, and thence upon a 24-in. belt-conveyor to the bedding bins. The portion caught within the drums (a tenth sample) drops out upon a 12-in. belt-conveyor, when, as the drum revolves, the slit opens downward.

Before the 24-in. belt-conveyor takes the stream of sticky concentrate, it is sanded by a thin stream of a peculiar lime-sand from a deposit near the Great Salt Lake. This thin coating prevents the sticking to the belt of the falling stream. The sample dropping on the 12-in. belt goes to a smaller wire chopper, and to a drum where a one-fifteenth sample is cut out, this sample then proceeding on a 10-in. belt-conveyor to a 1-ton mine car. The car travels with the sampling machine. A separate car is used for each 75-ton car unloaded. Copper concentrate is unloaded and sampled at the rate of 75 tons per hour at a cost of 10 cts. per ton. Table concentrates are sampled even more easily. The machine works to best advantage upon large lots of fairly uniform grades where no clean-up between lots is needed.

Steel Stacks or Chimneys, Lined or Unlined.[1]—Unlined steel stacks have not given satisfactory service when used for roasting or reverberatory furnaces, but they have been successful for long periods when used for blast-furnace or converter gases.

Building-tiles serve well either for chimney linings, for the construction of walls for flues, or for dust-chambers exposed to roaster gases, or

[1] *Min. & Met.*, Nov., 1920.

even for the cooler reverberatory-furnace gases. Bricks have proved successful where tile has failed.

These conditions apply also where waste-heat boilers are used in connection with reverberatory furnaces.

Reverberatory Smelting Practice.[1]—According to Charles F. Mason, the following details of practice have been developed in the Arizona field.

Oil consumption has been brought to an average of 0.7 bbl. per ton smelted. However, powdered coal is increasingly in use, as being cheaper than oil and quite as reliable. Using a fair grade of coal, as little as 19 to 20 per cent. is now required.

The straight-line arch, maintaining its height from the firing end to the front, is now being employed with satisfaction, being quite as economical in fuel as where a verb-arch is used. In this connection larger uptakes and flues are an advantage in the better recovery of waste heat.

Side-charging has proved its worth, the ore being dropped where experience suggests, sometimes for the first 22 ft., to correspond to the length of the blow-pipe flame, but at any rate according to the rate of melting.

Drag-conveyors now carry the charge from the hoppers to the side charge-holes with but little dust loss. Their chief objection is that the charge is more cooled in transit than where delivered into the charge-pipe.

Furnaces 90 to 100 ft. long are now standard, but it has been found to be an advantage to increase the width, especially where fine material that runs is smelted.

Continuous skimming or rather a continuous slag-flow is preferred, the covering crust being retained. Where this contains high-grade material, it is the practice to throw powdered lime upon it near the front and agitate the whole by means of air-jets. Thus it is fluxed, so that it can be removed before skimming.

At one plant a forehearth is being added through which all the slag can flow, and be cleaned by the addition of raw sulphide.

With a liberal uptake and short flue the waste-heat boilers are more effective, so that 4.7 lb. of water is evaporated per pound of coal used in the furnace. Where the ash drops down from between the tubes when blown out by compressed air, provision should be made for its ready removal.

Side-charging of Reverberatory Furnaces.[2]—J. O. Ambler, superintendent of the Arizona Copper Co., describes the continuous side-feeder designed for a 25 by 100-ft. reverberatory furnace. It is essentially a 6-in. tuyere-pipe inserted horizontally into the side wall, 12 in. below the spring of the furnace-arch. An inclined-bottom overhead bin, beside the furnace,

[1] *Eng. Min. Jour.*, **109**, 1071 (1920).

[2] *Eng. Min. Jour.*, **111**, 226 (1921).

connects by an inclined pipe to the feed-pipe, and the calcine is fed by a screw-feeder, as is done in feeding pulverized coal, all as shown in Fig. 6.

The advantages of this method of feeding are: (1) Dusting will be eliminated, decreasing the internal wear and fluxing of roof and flue-passages. (2) Better utilization of the heat will be effected, resulting in saving in fuel and increased tonnages, since then there is no variation of furnace temperatures due to charging. The charge being pushed in from behind, the surface exposed to the flame is kept at the highest temperature for effective melting. (3) Air will not leak in as in other methods that tend to cool the furnace. (4) The spring of the furnace-arch, now un-

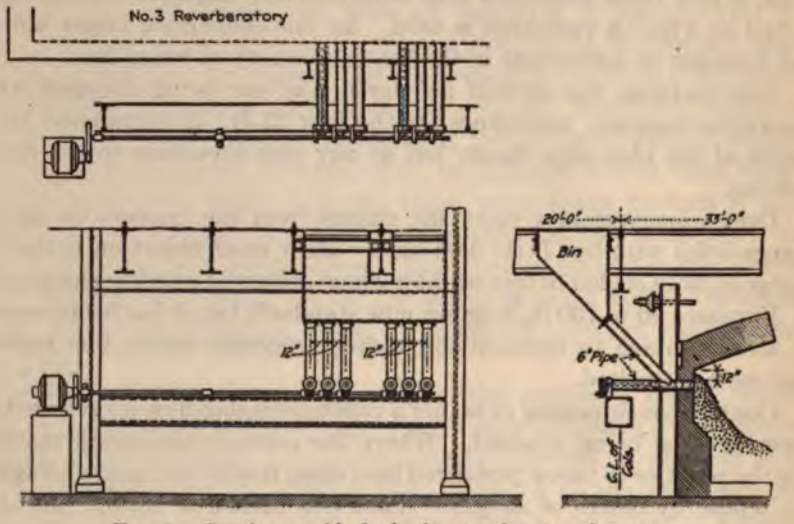


FIG. 6.—Continuous side-feeder for reverberatory furnace.

exposed, will last longer. Experiments indicate that it will be feasible to feed high-sulphur concentrates, either wet or dry, utilizing their heat of combustion here instead of at the roasters. An air-pipe of square section, shown beneath the feed-pipe, indicates the feeding of some air, when needed to supplement the burning of the sulphides. It is expected that due to better settling conditions slag losses will be less, as also dust losses to the stack, and less dust will be settling on the charge and in the outlet flues.

The Quincy Smelting Works, Hancock, Mich.[1]—In remodeling this plant there will be put in a new reverberatory furnace, 32 ft. long by 16 ft. wide, a 22-ft. automatic casting machine for shapes and anodes, a 12½-ton electric-motor crane to charge the furnace; a 6-ton crane to

[1] *Min. Sci. Press*, **121**, 388 (1920).

serve the casting room, a slag-pot of 2¼ tons capacity, operated by an electric trolley and battery locomotive, and a truck with a lifting frame which will carry the refined copper from the casting machine to the docks. The new furnace will be of 130,000 lb. capacity, as compared with the present maximum of 55,000 lb. The total capacity of the improved plant will be 230,000 lb. daily, as compared with 140,000 lb. at present. The electric locomotive, operating on overhead tracks, will spot the cars for the electric cranes, and the latter will pick them up and charge the "mineral" into the furnace, thus replacing the arduous duty of charging by hand.

Converting

High-speed Turbo-compressor.[1]—For blowing matte to blister in converters of the Pierce-Smith type at the copper smeltery of the Corporacion Minera de Famatina, Chilecito, northwest Argentina, there is used a high-speed turbo-compressor of the Rateau-Battu-Smoot type. The machine is rated at 4000 cu. ft. of free air per min. at 13 lb. pressure, with a shaft velocity of 22,000 r.p.m.

The machine runs smoothly, even at 26,000 r.p.m., due to massive construction and satisfactory dynamic balance of the rotor. The babbit-lined bearings are lubricated by oil flowing under pressure from an overhead tank at 10 lb. pressure. Speed regulation is obtained by means of a small control-fan attached to the end of the turbine-shaft, its air-pressure varying with the square of the speed of the rotor. This operates a static regulator controlling the steam supply.

The floor space occupied is but 4 by 7 ft., with a height of 4 ft. above the floor. As compared with a reciprocating blower of the same capacity the cost is one-half, the net weight one-eighth, the floorspace occupied one-seventh, the concrete for foundations one-fifth, railway and ocean freight to the mines one-seventh, and erection-cost but one-third.

Converting High-grade Matte.[2]—H. C. Robson discusses the conversion of matte of 55 to 60 per cent. copper in a 10-ft. Great Falls-type or upright converter, lined with magnesite brick, and on which a magnetite lining was formed. As not more than one charge of matte was available per day, the brick work of the lining would cool between charges, and had to be heated up with coal before blowing matte. An accumulation of secondary material (settler accretions and old furnace-bottoms) had also to be treated, some pieces weighing as much as 1½ tons. This caused abrasion around the tuyeres, so that they had to be relined after the treatment of 3,000,000 lb. of blister copper.

Charges to yield 11 tons of blister copper are preferred since the back pressure is moderate, and the charge is quieter, not tending to close the

[1] *Eng. Min. Jour.*, **110**, 717 (1920).

[2] *Bull. Inst. Min. & Met.*, Oct., 1920.

converter mouth by slopping. Indeed, less than 1 per cent. of flue-dust and barrings is collected, and of the latter little sticks to the mouth if this is clayed after each charge.

A new converter-shell is lined with basic brick, and this is coated with a magnetite lining for its protection, proceeding as follows: About 5 tons of matte is charged with the necessary flux, and, with the lowest possible pressure, is blown to white metal. The slag is then skimmed and 5 tons more of matte is added, but without flux; then 1½ tons of matte in lump form is gradually charged, and the whole is blown to blister copper without skimming, taking care that the air-pressure is moderate. If the operation is finished with the slag at proper temperature, the magnetite produced in the process will adhere to the lining. If it is seen that this temperature is getting too high the trouble may be overcome by tilting the converter to cause the tuyere to blow over the surface of the charge, and until the just-formed magnetite has cooled enough to adhere to the brick. The converter is then righted and the charge is blown to blister copper.

In normal operation, with the high-grade matte here treated, thermochemical reactions are at first sluggish, and it takes 15 to 20 min. before the charge will take the air properly, that is, before it starts to make slag. At this time much magnetite forms, but less if a good air-pressure is used, and the lining pre-heated before blowing the charge. The more air blown in, in a given time, the more heat is produced, while radiation and conduction losses remain the same. For matte of 65 per cent. and over, the author thinks the converter air should be preheated in an iron-pipe stove as in iron blast-furnace practice, by means of the converter gases, and arranging the stove for by-passing these gases.

Converter slag of from 55 to 60-per cent. matte will run from 6 to 9 per cent. in copper, the slag then getting so thick that it must be skimmed. Drawn out thus upon the floor, it solidifies and is broken up to be put into the next charge. Large amounts of cold materials are added to the converter charge in form of matte, settler accretions, black copper, refinery slag, old furnace-bottoms, barrings, flue-dust and thick slag. These, during the first part of the blow, are added from a small hopper situated above and at one side of the converter. Additions of scrap iron helped in heating the charge, but not coal.

At first punching tuyeres was hard work, but this was overcome by oiling the punching rods to prevent sticking. A blister copper of 98.8 per cent. was made, since in attempting to carry the blow farther the charge was cooled too much. The same ladle was used for both slag and blister copper, the slag giving a convenient lining and heat for the later-poured blister.

The converters were operated for three years, producing 3,000,000 lb. of blister copper of 98.77 per cent. before they had to be re-lined with brick. The patching was then principally at the tuyeres, where the lining came in for much mechanical wear, due to punching the tuyeres and to the large amount of cold material charged. It took 1⅓ tons of magnesite brick and mortar to make the repairs, which at £16 19s. 8d. figures out 4.18d. per ton of copper produced.

We show in Fig. 7 the course of events in blowing. The temperature-rise during the first 7 to 15 minutes is small, due to the cool state of the converter lining, and it is then most of the magnetite is formed. The No. 1 charge was the hottest, and started to make slag the quickest, this slag containing 3.44 per cent. Fe_3O_4, while No. 3 slag contained 6.84 per cent.

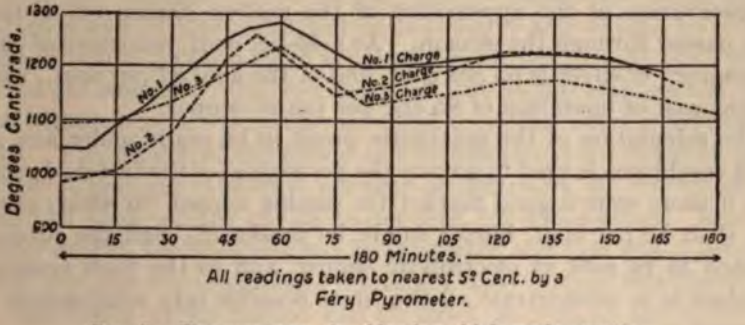


FIG. 7.—Temperatures in blowing high-grade matte.

The drop in the slagging period was due to the extreme cold weather then prevailing. The charge in these three cases was 11 tons of matte which yielded 5.5 to 6 tons of blister copper and about 4 tons of slag.

The blowing period varied from 143 to 157 minutes, and slagging for 15 to 22 minutes. Calculated from the displacement there was used nearly 500,000 cu. ft. of free air brought to 12.5 lb. pressure, or 8400 cu. ft. of air per ton of blister.

Selective Converting at Clifton, Ariz.[1]—The copper bullion here produced contained in 1920 of silver 4.83 oz. and of gold 0.150 oz. per ton, and was therefore too low in these metals to pay for an electrolytic parting expense of $25.00 per ton, to balance which a better price for cathode copper of 1 ct. per lb. would be required.

In the Welsh best-selecting process, bottoms are made from white metal in the reverberatory, these bottoms (a lesser part of the whole) carrying the gold and silver as well as the impurities or traces of alloying metals, the residual white metal being therefore improved in quality.

[1] *Eng. Min. Journ.*, **111**, 207 (1921).

A process, carried on in the converter, was successfully evolved, as had been done already at the O.K. mine in Western Australia.[1]

In operation a 50-ton charge of matte is blown in a 12-ft. Great Falls-type converter, with the usual addition of silicious ore and cleanings, to the white-metal stage. This white metal is then further blown until part of it is converted to copper, the blowing time being dependent on the amount of white metal and the percentage of blister desired. With this 50-ton charge, containing say 14 tons of copper, the blowing time to produce 55 per cent. or 7.7 tons of copper averages 50 to 55 min., but this varies with the cleanness of the skimming, the temperature of the charge and of the blast-air, the amount of scrap fed, and the operating conditions, dependent on the skill and experience of the operator. When to stop pouring the supernatant white metal from the copper is indicated by observation of the appearance of the molten stream on a rabble-blade passed through the stream. At a 55-per cent. reduction of copper, the recovery of silver is 65 per cent. and of the gold 87 per cent., with an incident cost of operation of 85 cts. per ton of copper.

The calculation of the maximum profit to be made under any given selling conditions is used to govern the percentage of the enriched product. Even if there were a good market for casting copper (in which case not more than 10 per cent. blister would be produced), half the product is expected to be sold as electrolytic copper, and so the most economical procedure is to concentrate all the silver possible into what copper is in any event to be refined.

Electrolytic Refining

Principles of Design of a Copper Refinery.[2]—Lawrence Addicks, from his extensive experience, tells what are the important principles of design and construction.

North America has produced most of the world's copper, often from consolidations, each capable of supporting a large refinery, so that 80 per cent. of this refining has been conducted in the United States. The most favorable location for copper refineries has proved to be in the vicinity of New York City, because at that point rail shipments from Western smelters and ocean arrivals from South American works conveniently join steamship deliveries to Europe and railroads to New England mills, and to other adjacent manufacturing works which are consumers of copper. Due to nearness to the refinery, orders of the desired shapes needed can be promptly filled even to the European customer. Were the refinery at the distant mine there would be a long time

[1] Mineral Industry, **23**, 222 (1914).
[2] *Chem. Met. Eng.*, **23**, 193 (1920); Mineral Industry, **28**, 220 (1919)

between the production of a wirebar and its actual rolling, so that the check on the quality of the bar would not be so close. The New York refineries have also had advantages in a suitable coal for furnace work, good boiler-water and plenty of it for condensing. We may therefore conclude that a refinery should be located with reference to copper freights, rather than to cost of power, and in such locations steam power is cheaper than hydro-electric power.

A plant of 100,000 tons annually is taken as ideal, and figures are given based upon this capacity. With thirty pairs of 3 by 3-ft. electrodes per tank, and an average current density of 20 amp. per sq. ft., the current on a circuit becomes 10,800 amp. With a current efficiency of 85 per cent., this current will produce 17,258 lb. of electrolytic copper per tank per month, or 575 lb. per pair of electrodes. The spacing center to center of electrodes will lie between 4 and 4½ in., so that the column of liquid between them is about 1¼ in. across. At low current-densities the anode is dissolved about as fast as the cathode builds up, but at higher densities the cathodes must be pulled more often than the anodes. The weight of the anode can be calculated by multiplying the expected output per tank-day, per pair of electrodes, by the life in days determined upon, adding to this 15 per cent. for anode scrap. From the area and weight, the thickness can be calculated and this, plus 2 times 1¼ in., will give the anode spacing. With the daily output established, the total number of tanks needed can be fixed, as well as the number of circuits. The voltage per tank may be established at 0.35 volt. To the total of tanks thus computed must be added the liberator and the stripper tanks. The liberator tanks take a pressure of 2.2 volts or, when the copper is to be completely removed, 2.5 volts. Ten stripper tanks (for the starting sheets) will take say 0.50 volts each. Allowing for defects in production, and on the basis of two starting sheets per stripper blank, we may figure that each regular tank will demand the equivalent of three such sheets per day, while each stripper tank will produce 38 sheets per day. Where the copper is completely removed from the electrolyte diverted from the regular circuit when too foul at the liberator tanks, ample provision should be made for their low current-efficiency where this diverted electrolyte is used for making bluestone. Tank-space should be provided according to the output of marketable bluestone needed, equal to 58 cu. ft. per ton per month. As to impurities removed, it must be remembered that a large part of the copper in the bluestone comes from towers carrying copper shot where the acid solution is neutralized. The author states that for each 1000 cu. ft. of crystallizing space allowance should be made of 175 cu. ft. at the shot-towers; for 375 cu. ft. in the shot-tower receiving tanks; for 225 cu. ft. in the slime-settling

tanks; for 250 cu. ft. at the boiling tanks; and for 275 cu. ft. in the scrap-iron precipitating or cementation tanks.

For smooth operation in the 100,000-ton plant there should be three anode and three wirebar furnaces. Allowing for Sundays and holidays, we should have accordingly 600 charges a year of 330,000 lb. each, plus some scrap added. This is easily managed, since with three doors and with crane-charging, as well as mechanical ladling, as much as 500,000 lb. can be handled. With hand-charging and hand-ladling, using the same men for both operations, 60,000 lb. is a large furnace charge, though if a fresh crew and many ladlers be used for charging 100,000 lb. can be reached. With hand-charging and mechanical ladling 300,000 lb. is possible, while, by the use of three charging doors per side, and of one charging and two ladling machines, much more than 500,000 lb. can be treated in 24 hr. Fuel economy increases with the size of the furnace, so that where a 60,000-lb. furnace takes 23 per cent. of fuel, and one of 100,000 lb. 18 per cent., a 300,000-lb. furnace can be run on 12 per cent. fuel, reckoned on the copper charged. Small furnaces, lined with silica brick, produce excessive slag, so that a 40,000-lb. one would yield 4 or 5 per cent. of slag with a wirebar charge, while a 150,000-lb. furnace would give but half that amount. Where a furnace is fully lined with basic brick, and is operating on a charge of good quality, the slag production may be held down to 0.5 per cent.

The first principle in the operation of the refinery is that all impurities possible should be eliminated at the basic anode furnaces, since it is more expensive to throw this to the electrolytic tanks. The second principle is to do all possible to insure uniformity of operation, so that anodes of uniform composition, a uniform current-density and a singly-composed electrolyte shall be used throughout the tank-house.

The Problem of Power and Heating in Copper Refining.[1]—That fuel and steam are needed, as well as electric current, in the refinery, calls for the use of waste-heat boilers, and so in general steam-driven electrolytic generators are employed. The ideal steam-driven plant would therefore be one where the steam yielded by the waste-heat boilers would supply the power requirements, the exhaust from which would be used for heating, and the resultant condensed water used at the water-jackets and so back to the boiler. This result has, thus far, never been reached.

The Waste-heat Boilers.—There being two furnace operations upon the material refined, and as the anode furnace treats about 15 per cent. of scrap, and as other materials are treated in both furnaces, we may count on a 25-per cent. consumption of coal, based on output. The waste-heat boiler, with aid of an economizer, will give an evaporation of

[1] *Chem. Met. Eng.*, **23**, 275 (1920); Mar. 15, 1917; *Eng. Min. Jour.*, **99**, 892 (1915).

6 to 7 lb. of water per pound of coal burned, so that there is available 1.5 lb. of water per pound of output. Though the coal consumption is fairly constant, yet there are great differences in the temperature of the gases leaving the furnace, this being low during charging and melting, and highest during the shorter period of skimming, poling, and especially pouring. Where there are say half a dozen furnaces, their operation may be so staggered as to give a pretty uniform steam supply. With the boiler set close to the furnace, and with cracks well closed, a temperature of 900° C. can be gotten in the boiler fire-box, and the exit gases may be brought down to about 290° C.

With a density of current, as in ordinary practice, of 18 amp. per sq. ft., and a temperature of the electrolyte of 55° C. (130° F.), the consumption of current will approximate 350 kw.-hr. per ton of copper deposited, or a refinery of 100,000 tons yearly would need a power capacity of 4000 kw. A thoroughly modern prime-mover can deliver a kilowatt at the switch-board with the consumption of 15 lb. of steam; we therefore need at the throttle roughly 2.6 lb. of steam per pound of copper refined, or nearly double the 1.5 lb. available from the waste-heat boilers. Where cheap hydro-electric current is available, this would of course be used. We have such a case at Great Falls, Mont., at Tacoma, Wash., and to some extent at Baltimore, Md. On the other hand we have at Chuquicamata, Chile, the case of a steam-generating plant transmitting current from the sea-coast (where the coal is) to the leaching plant inland.

As between reciprocating engines and steam turbines, the following considerations hold: To produce the 4000 kw. three reciprocating engines of the practical size of 1333 kw. would be best. A unit of 1333 kw. operating at 150 lb. gage-pressure, with 60° F. of superheat and 27½ in. vacuum, might be a two-cylinder compound or a four-cylinder triple-expansion engine; in the first case needing 17.5 lb. and in the second but 15.5 lb. of steam per kilowatt output.

In sizes of 1333 kw. the turbine reaches a high economy, so that with 170 lb. gage-pressure, 150° F. superheat and 28.5 in. vacuum, and after allowing a 7-per cent. loss in converting from alternating to direct current, as little as 13.5 lb. of steam would yield 1 kw. The advantages of the steam turbine are first its compactness, and second its ability to use high superheat and vacuum. One inch of vacuum or 50° F. of superheat will vary the rate 5 to 6 per cent. On the other hand a high vacuum calls for the use of water, increasing in amount as its temperature is higher. Thus at 50° F. and 28 in. of vacuum, there would be needed 28 lb. of water per pound of steam condensed, while at 70° F. the quantity has risen to 62 lb. of water per pound of steam.

The Electric Generator.—The tank-house circuits demand (*a*) direct

current, (*b*) high amperage or heavy current, (*c*) low voltage, and (*d*) wide voltage range.

(*a*) Where a steam turbine is connected to an alternating-current generator, this calls for a rotary converter to change to direct current. (*b*) A current of 10,000 to 15,000 amp. per circuit is now used, as it is possible to build larger-capacity commutators, but it has been found that for full duty, sometimes at low voltages, commutating conditions are severe, and any roughening of the commutator surface becomes rapidly worse. (*c*) The pressure is limited to 200 volts or less with a maximum current of 3000 kw., while 10,000 amp. at 120 volts, or 1200 kw., would represent present practice. (*d*) Voltage regulation is best accomplished by hand-control. With reciprocating engines the speed can be altered at the governor to the best cut-off; with ordinary direct-current generators the hand rheostat gives good voltage-control. A circuit of 120 volts pressure would have 360 tanks in series, and when drawing copper, say 36 tanks would be cut out, and this would call for a 20-per cent. cut in the voltage. On the other hand, with the tank-house operated on a constant current, the amperage would increase. The direct-current steam turbine has given satisfaction, though there is a practical limit to the size of commutator to be used, due to the high speed required. A two-cylinder compound engine, driving a direct-connected generator, the engine exhausting to a direct-current turbine connected electrically in parallel, makes a satisfactory unit as having a steam consumption of but 16 lb. per kw. based on a 2000-hp. machine.

Steam Consumption.—In heating the electrolyte, Eastern refineries expend 0.75 lb. of steam to raise its temperature by 30° F., equal to a power-saving of 15 per cent. That is, if we are using 3 lb. of steam (including auxiliaries) at the engines per pound of copper, this will be 0.45 lb. instead of 0.75 lb. needed to the electrolyte heating coils, and so heating with live steam would not pay. The water condensed from the heating coils is used for washing the anodes and cathodes from slimes, bluestone crystals, etc. The silver refinery and the bluestone plant will use perhaps 10 per cent. of the total steam. Under full-load conditions, we may compute 10 per cent. of the exhaust steam for further heating of the water at the economizers. For miscellaneous use, we should figure on a good deal of pumping needed in circulating the electrolyte and the bosh-water, supplying condensers, the fire system, the general water-supply, feeding boilers, and for the high-pressure hydraulic-cylinder system. There is also to be considered the compressed-air system for operating the copper hoists and pneumatic tools. Power is needed for the motors, driving cranes, shop tools, ventilating fans, sampling drills, and, in some cases, an industrial railway. Finally there is the lighting system.

Subjoined we give a summary of the requirements. This shows that of the total steam requirements 37 to 50 per cent. is needed for electrolytic power (condensing), 19 to 20 per cent. for light, power, water, air and auxiliaries; 10 to 25 per cent. for evaporating (using live steam) and 19 to 20 per cent. as exhaust steam for heating.

	Pounds of Steam per Pound of Copper.
A. Electrolytic power, condensing	2.5 to 3.0
B. Light, power, water, air and auxiliaries, non-condensing	1.0 to 1.5
C. Evaporating, live steam	0.5 to 2.0
D. Heating, exhaust steam	1.0 to 1.5
E. Total steam demand, $A + B + C + D$	5.0 to 8.0
F. Exhaust steam for *D* from *B*	1.0 to 1.5
G. Contributed by waste-heat boilers	1.5 to 1.5
H. Net steam demand, $E - (F + G)$	2.5 to 5.0

United States Metals Refining Co., Chrome, N. J.[1]—This works is situated 15 miles southwest of New York City. The plant handles custom copper and matte, gold and silver ores and scrap metals. There are two blast-furnaces, three converters, seven reverberatory refining furnaces, and in the electrolytic department 1225 tanks operated on the multiple system. The copper is cast on Walker casting machines. The production in 1919 was approximately 80,000 tons of copper, 165,000 oz. of gold, 8,500,000 oz. of silver, 125 oz. of platinum, 250 oz. of palladium and 1000 tons of nickel sulphate. In full operation 1200 men are employed and 6700 boiler-horsepower generated.

Raritan Copper Works, Perth, Amboy, N. J.[2]—This works refines blister copper and anodes from Anaconda, Mont., from Miami, Ariz., and elsewhere. It produces refined copper in all commercial shapes and, as by-products of the refining, gold, silver, copper sulphate, nickel sulphate, selenium, tellurium, tellurium oxide, platinum and palladium.

In the furnace department there are five anode furnaces, and six refining furnaces, these latter of a combined capacity of 2,300,000 lb. of copper per day, the anode furnaces slightly less. The electrolytic department, which requires a current of 14,000 kw., has two tank-houses, one having 1800 and the other 1656 lead-lined tanks. The parting of the gold and silver is done electrolytically by the Thum and Moebius process, and the gold is subsequently refined by the Wohlwill process. The plant, when running to capacity, employs 1400 men, and in 1919 produced 288,000,000 lb. of copper.

The Perth Amboy (N. J.) Refinery of the American Smelting & Refining Co.[3]—Established in 1894 as a lead refinery and a tin smeltery, this plant is noted for the size and variety of its operations. In the copper refinery is treated blister copper from the company plants in the United States and Mexico, blister copper and matte from South America, and copper-

[1] *Eng. Min. Jour.*, **109**, 1299 (1920).
[2] *Eng. Min. Jour.*, **109**, 1299 (1920).
[3] *Eng. Min. Jour.*, **109**, 1299 (1920).

bearing products from elsewhere. In 1919 the works, including the lead and copper refinery, yielded approximately 250,000 oz. of gold, 30,000,000 oz. of silver, 140 oz. of platinum, 125 oz. of palladium, 35,000 tons of lead, 70,000 tons of copper. The tin smeltery produced 7500 tons of tin. When running to capacity 1800 men are employed, and 7000 hp. is then required. A recent installation is a reverberatory refining furnace fired by means of powdered oal.

Nichols Copper Co., Laurel Hill, N. Y.[1]—This works, situated on Long Island, in the outskirts of New York City, refines copper from the Phelps-Dodge properties in Arizona, from the Calumet and Arizona Co., Ariz., and from the Granby properties, Anyox, B. C., principally, and does a large custom business besides. This latter includes the treatment of matte from Mexico, ore and concentrate from Cuba, ore, matte and concentrate from South America and Africa, as well as blister copper from Arizona, Montana and British Columbia. For the treatment of the matte, ore and concentrate, there is a blast-furnace and converters. The anode copper is treated in the electrolytic plant of 550 tanks, operated on the series system, and needing 5600 kw. The principal products are refined copper in commercial shapes and blue vitriol, also the usual by-products of such refining. The plant, when running to capacity, yields 550,000,000 lb. annually, employing 1600 men. Its output in 1919 was 310,000,000 lb. of refined copper.

Copper Refinery of the Consolidated Mining and Smelting Co., of Canada.[2]—The electrolytic refinery of 20 tons daily capacity is being increased to 50 tons to take care of the product of the Canadian Copper Corporation. A copper rod-mill has also been built, also of 50 tons daily capacity.

Electrolytic Recovery of Copper from a Copper-cobalt-nickel Matte.[1]—The object of the process was to effect a separation from the matte of the copper (its principal constituent) and the other metals in solution. A copper-nickel-cobalt concentrate was roasted, then smelted in a blast-furnace for the production of a matte containing the three metals. This matte, coarsely granulated, was roasted down to 3 per cent. sulphur, then containing Cu 20 per cent., Ni 8, Co 2, and Fe 10 per cent., was leached with sulphuric acid to yield a solution containing Cu 3.5, H_2SO_4 3.0, Ni 0.4, Co 0.2 per cent., which served as the electrolyte. The residue of leached tailings carried Cu 12.0 per cent., Ni 7.6, Co 1.8, Fe 11.0, S 4.2 per cent. This residue was smelted in another blast-furnace, yielding an alloy which was cast into anodes, containing Cu 55.0 per cent., Ni 19.0, Co 6.0, Fe 10.0, S 9.0 per cent., also a slag, which was sent

[1] *Eng. Min. Jour.*, **109**, 1299 (1920).
[2] *Chem. Met. Eng.*, **23**, 136 (1920).
[3] *Min. Sci. Press*, **121**, 45 (1920).

back to No. 1 furnace for remelting. The anodes were cast as thick as 2¼ in. on the top and had stout lugs so that they would not break off in handling. Anodes of the above composition were brittle and porous, containing too much sulphur and iron, and should rather have been made in a reverberatory furnace.

The cycle of operations in leaching the calcined matte was as follows: The vat to be charged first received a wash from a previous charge that

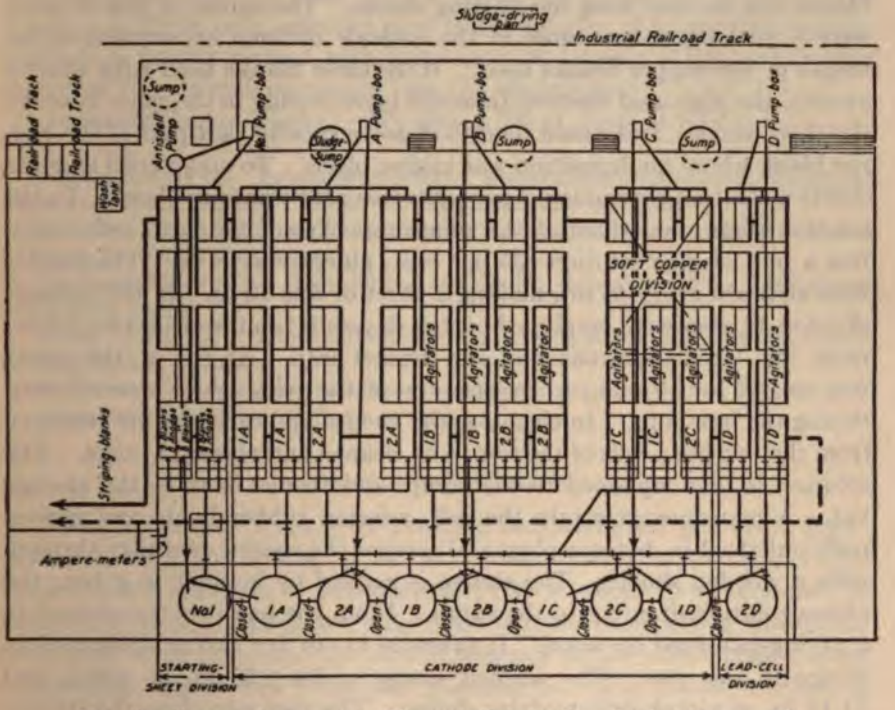


FIG. 8.—Copper department, Missouri Cobalt Co., Fredericktown, Mo.

had been strengthened to 8 per cent. sulphuric acid, and had been steam-heated to 80 to 90° F. the previous night. The matte was gradually dumped into the vat while the steam agitator was operating under 90 lb. pressure during a period of at least three hours. The resultant solution, now the electrolyte, was decanted to a storage-vat, and the residue received a water-wash, and was agitated for 30 min., the resultant liquor being then siphoned to the next vat preparatory to another cycle. The tailing, withdrawn by the discharge gate, was laundered to a tube whence it was wheeled to No. 2 blast-furnace. Provided the roast going to the leaching tanks analyzed below 3 per cent. sulphur and 10 per cent. iron,

and would pass through a 20-mesh screen, there was little trouble in making the required 45 tons daily of electrolyte carrying 3.5 per cent. copper from 12 to 14 tons of matte.

There are four subdivisions to the electrolytic plant, viz.: (1) the starting-sheet division; (2) the cathode division; (3) the soft-copper division; (4) the lead-cell division.

In the starting-sheet division two men were employed in stripping, weighing and carrying blanks to the hanging table. One man coated the blanks and one boy hung the starting sheets. The anodes of this division were 8 in. longer than those in the cathode division on account of the length of the copper blanks used. Were these blanks used with shorter anodes, the high-acid electrolyte would layer readily in the space beneath the short anodes, and would tend to dissolve rapidly that part of the copper blank where no deposition was taking place. To make good starting sheets a solution containing 3 per cent. free acid was found best. To the solution there was added at the solution-pocket of the head cell of each row a pint of glue solution (25 per cent. glue) every 8 hr. The anodes were stripped every 48 hr., making a sheet of 8 to 10 lb. In the cathode division 14 men were employed on the day-shift; on the other two, a foreman, one circulation man and one contact man. At 7 A. M. the power was cut off for 10 min., to by-pass ten of the cells, which were cleaned during the next 8 hr. In cleaning, the anodes and cathodes are removed from the two head cells of the row to be cleaned and placed in racks. The solution is then siphoned to the sump, and thence back to the storage vat. A man now gets into the cell, wearing rubber boots and gloves, pulls out the 2-in. bottom-plug, and scrapes the residue of sludge through with a wooden shovel. The sludge is carried by launder to a box, the excess solution draining to the sump. From the box it is transferred to a drying-pan fired by wood. It takes 24 hr. to dry two or three tons of sludge in this pan. The washed sludge yields 9.25 lb. of cobalt and 31.15 lb. of nickel per ton of dry sludge. The men who clean the 10 vats also remove the cathodes, weighing 40 lb. each, and place the new starting sheets and anodes. Each vat is cleaned twice per month, and cathodes should take 15 days to make. The electrolyte from the starting-sheet division flows in series through the cells *A* and *B* of the cathode division, through the cells *C* of the soft-copper division and finally through the cells *D* of the lead-cell division, as the subjoined analyses show.

	Acid, Per Cent.	Copper, Per Cent.	Iron, Per Cent.
Effluent from leach-plant	2.8	3.5	1.0
From starting-sheet cells	3.0	3.1	1.2
A cells	3.2	2.7	1.39
B cells	3.7	1.9	1.52
C cells	4.0	0.07	1.73
D cells	5.1	0.016	2.0

The author of the paper suggests the following improvements: (1) The use of Antisdell solution-pumps rather than ordinary pumps, so easily attacked by acid solutions; (2) the use of solid busbars; (3) lead-lined tanks; (4) the water-washing of the copper sludge from soluble metals; (5) use of asphalt flooring; (6) handling of sludge in lead-lined buggies; (7) the use of steam to maintain high temperatures of the solutions and so prevent crystallizing in the pipes, or else the use of open launders; (8) proper insulation of anodes and cathodes; (9) increased circulation and air-agitation in the cells *C* and *D* where the copper in the electrolyte is low. In these cells agitators were put, consisting of an air-pipe leading down to a header pierced with holes near the bottom of the tank for the escape of the air under pressure into the electrolyte.

Japanese Copper Works.[1]—We give a list of these as follows:

Kuhara Mining Co. Refineries at Oitaken, Kitaurubegari, Saganoseki, Hyagoken, Shikamagari, and Yejama. This is the largest producer in Japan.

Sumitomo, Besshi Mining Co. Refinery at Shikajima; the second largest producer in Japan (20,000,000 lb. per year).

Furukawa Mining Co. Mine and smelter at Ashio; refinery at Nikko; third largest producer in Japan.

Fujita Mining Co. Mines and smelter at Akitaken, Kazunogori, Kosaka; fourth largest producer in Japan.

Kinoshima. Refinery at Kinoshima; production about 3,000,000 lb. per year.

Mitsubishi Kogyo Co. Refinery at Osaka.

Copper and Its Alloys

Phosphor-copper Alloy.[2]—A product containing 15 per cent. phosphorus is made for adding to the melt when making copper alloys containing small amounts of phosphorus. Two methods have been used in producing such a high-grade alloy; one consists of smelting phosphate rock with copper ore, and the second depends on the direct combination of metallic copper and elemental phosphorus. The second method is the one generally used and has heretofore consisted of adding the phosphorus to the molten copper by means of phosphorizers, but this involves a loss of about one-fourth of the phosphorus and is dangerous to the operator. The method is accordingly modified as follows: The apparatus consists of a retort for distilling the phosphorus, this being connected to a container in which is placed the copper. The latter is in the form of clean copper scrap, such as wire or turnings. In operation, the phosphorus is placed in the retort, the copper in the container, and the joints are made tight with gaskets. The copper is heated to 400° C., then the phosphorus is distilled in the retort, its vapor passing

[1] *Eng. Min. Jour.*, **110**, 943 (1920).
[2] *Trans. Am. Inst. Min. Met. Eng.*, Oct., 1920; *Chem. Met. Eng.*, **23**, 768 (1920).

to and being absorbed by the scrap copper. Phosphorization to 15 per cent. phosphorus takes place at one step and with a short supply of the volatile metal, there is a sharp separation between the completely formed alloy and the unchanged copper adjoining, so that the two can be completely separated. The phosphor-copper is a black brittle mass, the freshly fractured surface having a bright lustre. The resultant mass sinters in lump form, and may be so used, or preferably may be melted under charcoal with little loss of phosphorus. Similar compounds useful in making the appropriate alloys have been made in the same way.

The Hydrometallurgy of Copper

Hydrometallurgy of the Copper Sulphides.[1]—W. E. Greenawalt recapitulates the advantages of the extraction of copper from sulphides when the metal can be recovered by electrolysis as the metal, so as to reduce shipping and refining costs to a minimum.

The outline of treatment should be roasting, leaching and the electrolytic deposition of the copper. Electrolytic plants, while expensive to install, can be used effectively in small units, especially when cheap power is available. On the basis of 1 ct. per kw.-hr., the power cost for deposition of 1 lb. of copper and the regeneration of the 2.5 to 3.0 lb. of acid needed for the leaching may be given at 1 ct., or for the total power cost, 1.5 cts.

Electrolytic methods are particularly efficient in the treatment of the higher-grade ores and concentrates.

Liquid Sulphur Dioxide as a Precipitant.[2]—The use of this chemical as a precipitant from the solution leached from copper ores has been adopted by the Andes Copper Co., and the process is being developed in the research department of the Anaconda Copper Co.

Reduction of Ferric Sulphate by Cement Copper at Ajo.[3]—A portion of the electrolyte, containing as much as 0.50 per cent. of its iron in ferric form, has been reduced to ferrous iron by agitating the solution with cement copper.

This solution is added to the reduced solution coming from the sulphur-dioxide towers, and the combined solution, forming the electrolyte, sent to the tanks. In this connection W. E. Greenawalt's patent on the use of hydrogen sulphide is interesting. He does not allow the ferric sulphate in the solution to exceed 0.25 per cent., and when it would an addition of sulphur dioxide is made. The resultant semi-liquid precipitate is pumped to those tanks that are most acid, and there re-dissolved, at the same time reducing the ferric iron to the ferrous state.

[1] Paper presented at western meeting of Can. Min. Inst.; *Min. & Met.*, Oct., 1920.
[2] *Eng. Min. Jour.*, **111**, 196 (1921).
[3] *Eng. Min. Jour.*, **111**, 196 (1921).

Copper Leaching at Rio Tinto.[1]—Courtenay de Kalb gives numerous valuable details of Rio Tinto practice, supplementing that in MINERAL INDUSTRY, **12**, 112 (1903); **15**, 288 (1906); **17**, 278 (1908). The leaching or cementation plant comprises three areas containing 18,500,000 tons of ore, also ponds to hold 6,000,000 cu. yd. and many precipitation canals and vats.

The following fundamental characteristics apply particularly to the Rio Tinto ores. The typical ore, mostly iron pyrite, contains 46 to 47 per cent. sulphur, and as, in leaching, the copper and about 2 per cent. of the iron is removed, the sulphur of the leached product rises to 49 to 50 per cent. Coarse pyrite is leached as readily as the fine, due to the fact that the copper no doubt exists as chalcopyrite and chalcocite upon its parting planes. The pyrite is fortunately attacked to but a slight extent, even after 15 or 20 years' exposure in the heaps. The pyrite, on removal from the leached piles, remains massive and undecomposed. Its shrinkage will average 7 per cent. The leaching is accomplished by oxidation of the copper sulphides in the presence of moisture, and successful operation is related to proper ventilation of the heap. The major portion of the copper is extracted in 3 to 4 years, the metal recovery paying for operating costs. The copper later recovered, as also the leached pyrite itself, represents clear profits.

A side-hill site with a grade of 10 per cent. is preferred for the roast-heaps, though some are built on ground sloping 2 to 3 per cent., and others around steep hills of 15 to 18 per cent. Large areas are covered, being extended down-grade, like a broad dump, and commanded by the train lines, built on contours to facilitate distribution of the ore. An ideal location would be a contour for the delivery train-line with a sharp descent to ground that flattens out again. Then bins can be built to receive ore from the mine-cars and from the bins, and the ore delivered over the widening pile, using cars of 1000 to 1500 lb. capacity. The depth of the pile on the side-hill varies from nothing on the up-hill side to a maximum of 32 ft. The coarser the ore, up to pieces of 12 to 18 in. in diameter, the deeper may be the pile. Fine ore does not extract so well. It yields 50 per cent. of the copper and the rest leaches slowly and imperfectly.

At Rio Tinto the ore-piles are barely wetted, using plain water, as also the spent liquors from the precipitation vats. Before active leaching begins, no water is added, but the moisture from the wet ground gradually rises into the pile. Fine ore is spread over the pile, in part to regulate its ventilation, in part to form a restraining bottom for the wash-water to be added. This top dressing is shaped up with low ridges into basins 4 to 6 ft. square, arranged for continuous flow from one to the

[1] *Min. Sci. Press*, **122**, 185 (1921); Bull. No. 3, Min. Met. Dept. de Fromento, Spain (1917).

other. As the pile gets moistened below in 4 to 6 weeks it heats up from the oxidation of the sulphur and iron, and the temperature may rise in spots to 150 to 180° F., but this is too high. The hot spots are tamped with fine ore and the pile is ready for the first wash. When it has been washed for a long time it is less active, oxidation is slower and less wash-water is needed. During the rainy season the piles are fully wet enough, and so the wash is materially reduced, but it will average 7½ gal. per day per sq. ft. of surface. When first laid the pile absorbs from 3 to 10 per cent. of its weight of water, but, after leaching and drying, will take up 10 to 12 per cent.

When the pile is given its wash it settles, and also shrinks in weight. The average may be given at 3 per cent., but with 3 per cent. copper in the ore this shrinkage will be 15 to 17 per cent. Including mechanical losses in removing the leached pile and in screening for market, the total losses will amount to 20 per cent. or more. The specific gravity of the solution is constant at 1.1, and the iron in it, both ferrous and ferric, will average 2 per cent.

Time is an important factor in leaching. After 3 or 4 years the upper 6 or 8 ft. of the pile will show an extraction of 80 per cent., during the next 6 or 8 ft. 60 per cent., and so on to the bottom. In 10 years the extraction has risen to 95 per cent., but it appears that after 30 years the pile will still yield some copper.

For successful leaching, alternation in the washing is of great importance. The wash-solution should slowly descend and wet the pieces of ore, giving time for penetration by capillarity. It should then be allowed to dry, and to draw in oxygen to complete the reactions.

The solutions entering the precipitation tanks carry an average of ferrous iron 1.92 per cent., ferric iron 0.14, Cu 0.35, Zn 0.20 per cent. The total SO_4 amounts to 5.92 per cent., of which 0.85 per cent. is free sulphuric acid. The barren solution or spent liquor will carry as ferrous iron 2.32 per cent., ferric iron none; Cu 0.0023; Zn 0.21 per cent.; while the total SO_4 has dropped to 5.55 and the free H_2SO_4 to 0.43 per cent. However, at some plants they do not dare to return the spent liquor to the leached piles, since then the basic iron salts are deposited on the ore, resulting in a stoppage of the extraction of the copper. In addition to the spent liquors (where used) the mine-waters are sent to the leached piles, these containing upwards of 0.06 per cent. copper. The copper solution going to the precipitation vats has always a deep emerald-green color.

The precipitation vats, built flush with the ground, are commonly 330 ft. long, 40 in. deep and 10 ft. wide, and have concrete walls lined with 2-in.plank.

In one plant there is 3500 linear feet of vat, including a series of 18-in. vats following the deeper ones. Both scrap iron and pig iron are used, the latter in the first vats. This pig contains 92 per cent. iron, and is high in graphite, this accumulating as a layer, sometimes ½ in. thick, between the copper coating and the iron. The weaker the solution, the slower should be the flow, so as to give time for complete precipitation, and this coating is of high grade (80 per cent. copper). The copper precipitate is washed over ¼-in. screens, 10 ft. wide by 33 ft. long, the leaf-copper collecting on the screens, the undersize going to the washing floors or planillas. The fine cement copper is here concentrated to a shipping product of 90 to 92 per cent. copper. The tailing from the planillas, containing much graphite, and of 40 per cent. copper, goes to settling vats. This tailing is dug out at intervals, and mixed with granular copper from the later or low-grade vats to make a 70-per cent. grade for melting. The average of the precipitate is about 70 per cent. metal. The iron consumed will vary from 1.4 parts to as high as 2.4 parts per part of copper, depending on the amount of ferric iron and of sulphuric acid in the entering solution.

The cost of extraction is given at approximately 4 cts. per lb., down to 3½ cts. On a basis of 2 per cent. copper in the ore and a 90-per cent. recovery, this would figure out $1.26 per ton of ore. The highest cost found was 6 cts. per lb. or $2.16 per ton of ore.

As to the silicious ore, existing particularly at the North Pit, Rio Tinto, this is of sericitized porphyry, containing 1.5 to as high as 9 or 10 per cent. copper as chalcocite. This rock is white and tinged with grey, where the chalcocite shows as seams in the rock, and is friable and granular. It is separately treated in leach-piles so as to allow of free ventilation.

The chalcocite oxidizes and leaches in the course of years, while fresh ore is added on top, no other treatment being needed. The ore resembles that from the Inspiration, Miami, and Nevada Consolidated mines, and could be treated by flotation, but leaching is considered to be more economical, even taking account of the long time needed, which may be as much as 10 years.

These silicious orebodies have seams that carry silver to as high as 50 oz., but commonly 10 to 15 oz. per ton. This silver ore is separately treated.

Leaching of Mill Tailings of the Shannon Copper Co., Clifton, Ariz.[1]— The process, as finally developed, consists in giving a slow oxidizing roast, using in so doing 1½ per cent. of raw pyrite. The copper sulphate is leached from the resultant calcine in a Dorr continuous counter-current

[1] *Eng. Min. Jour.*, **109**, 869 (1920).

washing system, and the copper in the pregnant solution is precipitated upon scrap iron. Over one million tons of tailings, averaging 1 per cent. copper, was available, and was treated at a cost of 13 cts. per ton, and with an extraction of 67 per cent.

The tailings of altered limestone and decomposed porphyry, containing Cu 1.07 per cent., SiO_2 62.0, Fe 8.0, S 1.0, Al_2O_3 13.3, alkaline earths 4.7 per cent., were excavated by a drag-scraper, taking care to so cut the sand and slime strata as to give a well-mixed feed. The scraper dumped into the boat of a bucket-elevator, and this discharged into side-dump cars. The loaded cars were switched 1½ miles to storage-bins of 300 tons capacity. From them it was drawn over a grizzly (to take out lumps and to promote mixing) into 5-ton feed-hoppers, and from them upon a 30-in. conveyor-belt supported by closely-spaced pulleys beneath the feed-openings. This assured a steady stream of feed.

The pyrite ore, of which but 1½ tons was used daily with over 100 tons of tailings, carried 45 to 48 per cent. sulphur and 42 to 44 per cent. iron. It was screened through 1½-in. round holes, and dry-ground to minus 100 mesh in a 3 by 5-ft. ball mill. The ground product went to a storage bin, and was in operation fed upon an 18-in. belt-feeder to join the main feed, first upon a 24-in. belt-conveyor, then on a 20-in. one, in order to deliver to the feed-hoppers of the Mac-Dougall roaster.

The roaster, 24 ft. inside diameter, has ten hearths, and one pre-heating hearth, with an effective hearth-area of 2580 sq. ft. Two opposite fire-boxes deliver pre-heated air of about 133° C. to the ninth hearth. (One fire-box was finally found to be sufficient.) The walls are double, the inner wall of red brick, 13 in. thick, separated by a 4-in. air-space from the outer 8-in. wall of hollow tile. The hearths are of reinforced concrete, except the tenth one, which is of cast-iron plates. These hearths are supported on steel beams carried on rollers that bear upon plates set in the 13-in. inner wall, so that expansion of the beams when heated is provided for. Both hearths and beams are durable under the carefully regulated heat used. On the outside-drop hearths the usual sand-seal joint is used at the central shaft. On the center-drop hearths there is a 2-in. expansion-joint at the periphery, sealed by cast-iron ship-lap plates loosely strapped together. These make a satisfactory seal. The 18-in. steel-pipe central shaft has two stubs welded to it at each hearth. These carry rabble arms of 5-in. extra-heavy pipe. The top hearth, however, carries four arms, in order to equalize the loading due to the damp feed. The shaft and its load is carried on a step-bearing made of a fibre-disc between two hardened steel discs. The side thrust of the shaft is taken by collars, top and bottom. The rabbles are of

sheet steel, except at the two top hearths, where a special hardened casting is preferred.

In operation an induced draft is produced by means of a 42-in. suction fan. The path of the air is downward between the walls, thence under the cast-iron bottom hearth, and around the sides of the fire-boxes to meet the oil flame from the burners. The heated air, passing upward through the roaster, is drawn vertically from the top hearth and down-take into a dust-chamber of hollow tile, and thence delivered to the stack by the 42-in. exhaust fan already mentioned.

The hot calcine discharges through a self-sealing hopper to a launder that leads to a grinding and leaching drum in the leaching department.

In the roasting operation the conditions tending to a maximum conversion of copper to copper sulphate are: (1) That the copper be brought to the form of an oxide; (2) that energetic catalyzers, viz., ferric iron and silica, be present; (3) that there be such a concentration of the forming sulphur trioxide in contact with the pyrite and catalyzers as will convert the copper oxide to sulphate. Magnesia, lime, zinc oxide and manganese oxide may also be sulphatized. The ignition temperature of pyrite is given as 325° C.; that of chalcocite as 430° C. If the roasting temperature is brought to as high as 650° C. copper sulphate decomposes, while the decomposition temperature of iron sulphate is 590° C. Hence the maximum temperature should be maintained in the narrow limits 590° to 650° C. in order to give a maximum formation of copper sulphate. The zone of reactions where the sulphates are formed are the highest on the upper hearths, where, however, the ore has not had the benefit of long contact with the oxidizing temperature needed for the conversion of copper compounds to copper oxide. If, however, the roaster gases were down-drafted, preferably with addition of pre-heated air under pressure, the oxidizing time would be increased, and a quick heating to reaction temperature would result over the well-heated ore of the lower hearths.

The roaster, of 150 tons capacity, was limited to an output of 110 tons by the leaching department. It yielded as high as 176 tons when sandy material with as little as 7 per cent. moisture was treated. The pyrite was used in such quantity as to give 1.4 lb. of sulphur per pound of copper. Above this, sulphatization decreased, and the ore got too hot. With less sulphur than this sulphatization, it is true, was high, but there was less ferric iron in the calcine, and the water-soluble content dropped. The air used depended on the fuel and ore-oxidation needs, and was limited to give the highest formation possible of sulphate. The rate of rabbling, depth of charge, and the time the ore is passing through

the furnace were independent. Thus with one revolution in 75 sec., with a 3¾-in. bed, and a treatment time of 10 hr., extraction and sulphatization were low, and there was no ferric iron in the calcine. The roaster was overloaded. Operating at one revolution in 45 sec., with a bed of 1¾ in. and a treatment time of 6 hr. (80 tons of feed per day), the extraction was a little below normal. Sulphatization was high, ferric iron was high, but the calcine was decidedly cooler for a given operating temperature. Following are the operating data as developed:

Feed average in moisture	15 per cent.
Daily tonnage	110 dry tons.
Pyrite used daily	1.5 tons.
Fuel-oil	5 gal. per ton of ore.
Temperature of air entering ninth hearth	521° C.
Roaster speed	1 r.p.m.
Treatment time	8 hr.
Depth of charge	2.92 in.
Pre-heated air	133° C.
Gas volume per minute at 191° C.	6800 cu. ft.
Flue-dust of total tonnage	0.8 per cent.
Temperature of calcine	470° C.
Average results:	
Total copper in feed	0.85 to 1.00 per cent.
Water-soluble copper	55 to 62 per cent.
Sulphatization	88 to 97 per cent.

Leaching.—The hot calcine was ground, then leached by a continuous counter-current system, the copper in the resultant solution being precipitated by scrap iron. The re-grinding of the hot calcine was done by using pebbles in a wood-lined revolving drum 4 ft. in diameter by 5 ft. long, with additions of barren or waste liquor of the precipitating tanks kept in storage (see Fig. 9). The ground calcine now passes to a Dorr classifier, which separates the sands that go to the tailing dam, and slime which goes through the Dorr thickeners, Nos. 1 to 3, from right to left and thence to the tailing dam. The clear pregnant solution, from thickener No. 1, passes now to the four scrap-iron-filled precipitation vats in parallel. These vats have false bottoms, one at a time being by-passed, so that it may be drained and washed for its accumulated precipitate to the decanting tanks adjoining. Fresh water is added at the third thickener and at the last deck of the classifier. Increased extraction of copper from basic salts and from oxides in the calcine was obtained by using as wash-water the barren solution from precipitation. The slime sent to waste carried but 0.02 per cent. soluble copper.

An average of 205 tons of pregnant solution was yielded daily. The copper precipitated from this required 1.6 tons of scrap iron per ton of copper. The precipitate obtained averaged Cu 60.4 per cent., iron compounds 7.9, metallic iron 0.8, S 1.4, insoluble 10.4 per cent.

The free acid in the strong liquors was less than 0.005 per cent., and its flow was changed daily, so as to pass them over freshly cleaned iron, the finer scrap being used for them.

Operating Costs.—In the period of 139 days from July, 1918, to January, 1919, there was treated 12,599 tons yielding 169,621 lb. of copper, or 13.46 lb. per ton, the extraction being 67.31 per cent. Costs for excavating, roasting and leaching based on 110 tons daily were:

Power, 77 hp. @ $9.45 per hp.-month		$ 727.00
Insurance, depreciation, analysis and supplies	$ 400.00	
Switching, 120 cars @ $2.50	300.00	
Fuel-oil, 5 gal. per ton @ $2.76	1085.00	
Sulphide ore, 45 tons @ $7.78	350.00	
Scrap iron, 1.6 lb. per lb. of copper @ 1 ct. per lb.	711.00	2846.00
Labor: Roasting and leaching (6 men)	851.40	
Excavating (3 men)	398.70	
General (5 men)	604.50	1854.60
Miscellaneous supplies	50.00	
Repairs and replacements	360.00	410.00
Total		$5837.60
Cost per lb. of copper produced		13.16 cts.

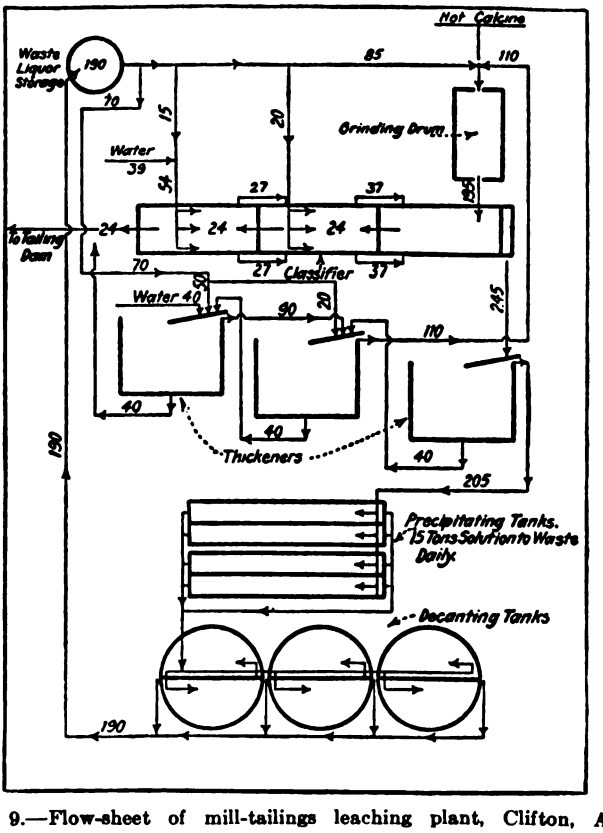


FIG. 9.—Flow-sheet of mill-tailings leaching plant, Clifton, Ariz.

Heap-leaching at Bisbee, Ariz.[1]—Jos. Irving, Jr. gives the method used by the Copper Queen branch of the Phelps-Dodge Corporation in leaching ore mined by steam-shovel at Sacramento Hill.

[1] *Min. Sci. Press*, **122**, 225 (1921).

A heap 2000 by 750 ft. is built of depth varying from 9 to 52 ft. and containing 3,000,000 tons of ore. The barren solution from the precipitating tanks, carrying much ferric sulphate, is pumped upon the heap and distributed to leach evenly through it. The precipitating plant consists of 12 Dorr precipitating tanks, where the copper is thrown down by scrap iron and washed free from the iron by agitating for a short time, the copper precipitate being then allowed to settle. The Dorr mechanism in the tank is now lowered, rotated slowly, the discharge-plug at the mid-

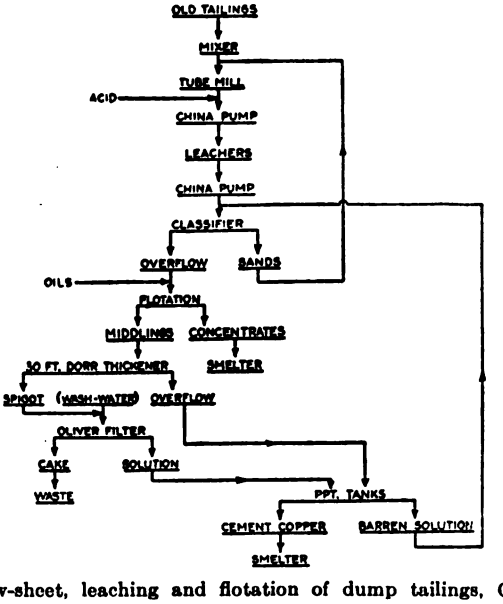


FIG. 10.—Flow-sheet, leaching and flotation of dump tailings, Clifton, Ariz.

dle of the tank pulled, and the precipitate discharged. This product goes to a Dorr classifier to separate the coarse copper from the fine, the coarse going to a drying floor to dry before shipment, while the fine goes to a Dorr thickener. The products of the thickener are a thickened product going to a drying floor, and a clear overflow solution, which is returned to the precipitating tanks.

The scrap iron is unloaded from railroad cars, and unloaded into the precipitating tanks by a 5-ton gantry crane. Two men per shift neatly operate the plant.

Leaching and Flotation of Tailings at Clifton, Ariz.[1]—We give in the flow-sheet, Fig. 10, the method preferred upon dump tailings, a mixture of "oxide" slime and slime tailings from a sulphide mill, the feed to the plant containing a total of Cu 1.36 per cent., consisting of acid-soluble

[1] *Eng. Min. Jour.*, 110, 471 (1920).

copper 0.79 per cent., water-soluble copper 0.13 per cent., and copper as sulphide 0.44 per cent.

As shown on the flow-sheet, the slime lumps are broken up by a log-washer, water being added to bring the discharge to 50 per cent. solids. This is picked up by the scoop-feeder of a tube mill, 5 ft. in diameter by 12 ft. long. The mill is lined with Danish quartz pebbles set in cement, the same pebbles being used for grinding. Sulphuric acid is added at the discharge of the mill, and the pulp delivered to three leaching tanks in series, using the counter-current tank system. Pulp is transferred from tank to tank by air-lifts. The leached pulp from the tank is delivered to a drag-classifier, which returns the sands to the tube mill for re-grinding. The classifier overflow is at once given an addition of oil, and is subjected to flotation for the removal of the sulphide copper. This operation gives two products, concentrates to be sent to the smelter, and a middlings product to be treated in a Dorr thickener of 30-ft. diameter. The clear overflow from the thickener is now ready for precipitation on scrap iron, while its thickened spigot-discharge goes to an Oliver filter for the removal of solution, the cake going to waste. The Oliver filtrate likewise goes to the precipitating tanks.

Sixty pounds of 60° acid is consumed per ton of dry material, or 2.17 lb. per pound of copper in the feed. The recovery of soluble and of sulphide copper was 84.57 per cent.

Details of Leaching Operations at Chuquicamata, Chile.[1]—In addition to the information given in MINERAL INDUSTRY, **23,** 259 (1914), **24,** 249 (1915), and **25,** 261 (1916), we add the following:

The mines and leaching plants of the Chile Exploration Co., a subsidiary of the American Smelting & Refining Co., are situated at Chuquicamata, 9200 ft. above sea-level, and 164 miles distant by rail from the seaport of Antifogasta. Power for the leaching plant is supplied from a power station at Tocopilla, on the sea-coast, where 25,000 to 30,000 lb. of fuel-oil is used monthly. The power-plant includes 4 steam turbines, driving a generator of 10,000 kw. The current is sent 95 miles to the plant by 3 cables, each of 7 wires, and is reduced at the plant to 5000 volts by means of four transformers. A 110,000-volt current is distributed through a large transformer station largely to the leaching plant, and to the 50 locomotives of the company's railroad, both at the plant and on the branch to Calima where it connects to the main line of the Antifogasta and Bolivian railway. The water for the leaching plant is brought a distance of 60 miles from near the base of the volcano of San Pedro, the system having cost about $1,000,000. The investment in the various properties above mentioned cost in the neighborhood of $100,000,000.

[1] *Min. Sci. Press,* **121,** 280, 405 (1920); *Vie Tech. & Ind.,* **1,** 12 (1919).

There is sufficient sulphuric acid obtained from the water-soluble copper sulphate in the ore by the regeneration of the acid in the electrolytic cells to obviate the necessity of adding manufactured sulphuric acid, and hence the elaborate acid plant at first put in has been abandoned. Owing to the fact that the ore is a combination of water-soluble sulphuric acid, of basic sulphate (brochantite), and of the oxychloride (atacamite), with several other copper minerals of much the same nature, the pregnant solutions contain chlorine in combination with copper as cupric chloride ($CuCl_2$). This chlorine has to be removed before the solutions are delivered to the electrolytic cells. To do this cement copper is mixed with the solution at the head of a series of agitation cells, transforming the cupric chloride to the insoluble form, according to the reaction $CuCl_2 + Cu = 2CuCl$, and this is settled out of the solution in Dorr thickeners. The clear liquid, the chlorine contents reduced to 0.05 to 0.15 per cent., is then sent to the electrolytic plant. The separated cuprous chloride is dissolved in brine, and the copper thus dissolved is precipitated upon scrap iron as cement copper to be used in dechloridizing subsequent plant solutions. In the electrolytic plant of 510 tanks the copper is deposited on starting sheets 4 ft. square, and on them the copper is built up until they weigh 250 lb. each. These cathodes are melted in oil-fired reverberatory furnaces and cast into regular wirebars.

The monthly production of copper is now 3000 to 4000 tons, and it has been planned to increase the capacity of the plant. The cost of production, including freight to New York and selling costs, is given at 14.5 cts. per lb.

The New Cornelia Copper Co., Ajo, Ariz.[1]—For the year ending Dec. 31, 1918, there was produced 29,640,211 lb. of electrolytic copper, 6,368,952 lb. of cement copper, and 3,500,298 lb. of copper in ores—a total of 39,509,461 lb. Beginning early in February, production was on a restricted basis for the remainder of the year 1918. During the period there was delivered to the mill 1,542,533 tons of ore, averaging 1.488 per cent. in copper. Besides this there was shipped to Douglas, Ariz., for smelting, 62,120 tons averaging 3.43 per cent. copper.

[1] *Eng. Min. Jour.*, **109**, 827 (1920).

CRYOLITE

The world is dependent for its supply of cryolite on the deposit at Ivigtut, Araukfjord, South Greenland, owned by Kryolith Mine and Handelsselskabet, A/S, Copenhagen, Denmark, which holds a state concession for the mining. The product is sold to the Pennsylvania Salt Manufacturing Co. of Philadelphia, selling agents for America, and to Oresunds Chemiske Fabriker, Kommanditselskab ved C. F. Jarl, Copenhagen, selling agents for all other countries.

The annual shipments of cryolite from Greenland are as follows, in metric tons:

	To the United States.	To Copenhagen.	Total.
1913	1,964	8,451	10,415
1914	4,139	7,373	11,512
1915	3,753	5,809	9,562
1916	3,773	9,812	13,585
1917	3,959	5,678	9,637
1918	1,916	8,802	10,118
1919	1,973	4,394	6,367
1920	5,024	8,904	13,928

The Department of Commerce reports the following imports for the corresponding years:

	Long Tons.	Value.	Value per Ton
1913	2,559	$52,557	$20.54
1914	4,612	94,424	20.47
1915	3,940	82,750	21.00
1916	3,857	165,222	42.83
1917	4,383	218,500	49.85
1918	1,950	97,500	50.00
1919	2,131	106,956	50.20
1920	3,864	193,638	50.11

Part of the United States imports are re-shipped to Canada, mainly for use in the Canadian aluminium industry. The Canadian imports, almost entirely from the United States, are as follows (for fiscal years ending March 31 of the succeeding calendar year):

	Short Tons.	Value.	Value per Ton.
1913	1,234	$50,905	$41.25
1914	1,075	44,683	41.56
1915	1,765	72,024	40.81
1916	860	87,146	101.33
1917	685	131,236	191.49
1918	732	137,258	187.43
1919	839	137,702	164.12
1920	865	153,500	177.45

FELDSPAR

By Arthur S. Watts

The feldspar industry has shown remarkable activity in production during 1920 although no new fields have been developed.

The output of North Carolina was practically twice the 1919 production and about 40 per cent. greater than the previous maximum production in 1917. This is due mainly to the entrance of a number of new mining and grinding companies into the field. Many new mines have been opened and some of these are showing great possibilities both in quality and quantity. The center of activity is along the C. C. & O. R. R. in Mitchell and Yancey counties. Twelve mines are operating in the district and there are now five grinding mills between Sprucepine, N. C., and Erwin, Tenn. Much of the crude feldspar is still being shipped to northern grinding mills, however.

Operations in Maine have increased 200 per cent. over 1919 figures and are 50 per cent. greater than the 1917 production.

Connecticut shows a distinct increase over 1919 figures, although the production for 1920 is 10 per cent. less than in 1918 and 1917.

Maryland has shown a gradual decrease in production since 1916, and in 1920 produced only 50 per cent. of the tonnage of 1917.

Pennsylvania has dropped from 10,000 tons in 1917 to 4,000 tons in 1920.

Canada, however, produced in 1920 more than two and one-half times the production of 1919, and nearly double the previous maximum annual production.

Production figures for 1919 and 1920 are as follows:

FELDSPAR PRODUCTION (a)

	1919.		1920 (c)	
	Short Tons.	Value.	Short Tons.	Value.
Production in U. S.				
North Carolina and New York (b)	34,679	$195,021	65,000	$365,000
Maine	14,387	206,659	46,000	514,000
Connecticut	10,880	133,113	9,000	120,000
Maryland	7,820	39,610	7,000	40,000
California and Pennsylvania (b)	3,288	10,797	4,000	60,000
Total	71,054	$585,200	131,000	$1,099,000
Production in Canada				
Ontario	13,754	$ 73,158	36,207	$264,023
Quebec	925	13,073	649	10,052
Total	14,679	$ 86,231	36,856	$274,075

(a) U. S. data from U. S. Geological Survey. Canadian data from Canadian Department of Mines.
(b) Combined to conceal individual production. (c) Estimates only.

TOTAL FELDSPAR PRODUCTION AND VALUES

	United States.		Canada.	
	Short Tons.	Value.	Short Tons.	Value.
1913	120,955	$776,551	15,935	$56,841
1914	135,419	629,873	18,060	70,824
1915	113,769	629,356	15,455	59,124
1916	132,681	702,278	19,488	71,407
1917	141,924	728,838	11,493	54,555
1918	99,120	674,346	20,232	117,379
1919	71,054	585,200	14,679	86,231
1920	131,000	1,099,000	36,856	274,075

To the list of companies grinding feldspar, which appeared in the reports of 1918 and 1919 in MINERAL INDUSTRY, the following should be added:

J. W. Cummings Feldspar Co., operating a mill at Bath, Me., and grinding Maine feldspar.

Product Sales Co., 32 S. Calvert St., Baltimore, Md., operating a mill at Baltimore and grinding Maryland feldspar.

Wheeling Pulverizing Co., Wheeling, W. Va., operating a mill at Wheeling and grinding Canadian feldspar.

Rock Products Co., Nicholas Bldg., Toledo, Ohio, operating a mill near Toledo and grinding Canadian feldspar.

Erwin Feldspar Corporation, Erwin, Tenn., operating a mill at Erwin, Tenn., and grinding North Carolina feldspar.

Carolina Feldspar Co., Asheville, N. C., operating a mill at Erwin, Tenn., and grinding North Carolina felsdpar.

Several other grinding mills are reported as under construction or to be constructed soon in the North Carolina field to grind North Carolina feldspar, and a company has been incorporated at Cleveland, Ohio, to grind Canadian feldspar.

FLUORSPAR[1]

By Hubert W. Davis and Raymond B. Ladoo

Shipments.—The fluorspar shipped from mines in the United States in 1920 amounted to 186,778 short tons, valued at $4,718,547, as compared with 138,290 short tons, valued at $3,525,574, in 1919. These figures show an increase in quantity of 35 per cent. and in value of 34 per cent. The shipments in 1920 are about 29 per cent. less than the record of 263,817 in 1918, reached under war demand, but are greatly in excess of the pre-war record of 116,545 tons in 1912.

The general average value per ton f.o.b. mines or shipping points for all grades of fluorspar in 1920 was $25.26, which is 23 cts. per ton less than the average value reported in 1919. The highest average value reported in 1920 was recorded in Kentucky, which was $27.05 per ton, and the lowest in New Mexico, which was $15.97 a ton. It should be noted that the differences in the average values reported do not generally represent differences in quality, but differences in freight-rates from the mines to the consuming centers, the values given being f.o.b. shipping points. Quoted prices on gravel spar were somewhat lower than in 1919, the price of 85-per cent. grade ranging from $22.50 to $27 per ton in the Kentucky-Illinois district. Acid lump spar was greatly in demand at prices from $50 to $60 per ton. The base price of gravel spar for 1920 was reported to be about $5 lower than 1919.

The demand for fluorspar was good the entire year with the exception of January and December, and at times little material was available for attractive deliveries. During the latter part of February a number of contracts expired, which, together with the depletion of stocks accumulated during the war period, forced many consumers into the market for fresh supplies. In June it was believed that there would be a shortage of spar during the last half of the year and that the price of fluxing material would be advanced. Despite the fact that shipments were being made under difficulty, due to the insufficient car supply, consumers began to press producers for delivery, the tendency on the part of steel-makers being to get large tonnages of spar in their bins. No data are available as to the quantity of fluorspar held by consumers at the end of 1920, but it is understood that the start of the slump left many users with large stocks on hand.

[1] Revised article printed as co-operative report of U. S. Geological Survey and U. S. Bureau of Mines, Feb., 1921.

FLUORSPAR SHIPPED FROM MINES IN THE UNITED STATES (a)
(In short tons)

State.	1919.			1920.		
	Quantity.	Value.	Average per Ton.	Quantity.	Value.	Average per Ton.
Colorado	9,687	$150,739	$15.56	12,852	$251,308	$19.55
New Mexico	2,346	37,643	16.05	6,353	101,460	15.97
Illinois	92,729	2,430,361	26.21	120,299	3,096,767	25.74
Kentucky	32,386	883,171	27.27	46,091	1,246,942	27.05
Nevada, New Hampshire, Utah, Arizona	1,142	23,660	20.72	1,183	22,070	18.66
	138,290	$3,525,574	$25.49	186,778	$4,718,547	$25.26

(a) Statistics of U. S. Geol. Surv.

SALES OF FLUORSPAR IN THE UNITED STATES, IN SHORT TONS (a)

Year.	Quantity.	Value.	Year.	Quantity.	Value.
1905	57,385	$362,488	1913	115,580	$736,286
1906	40,796	244,025	1914	95,116	570,041
1907	49,496	287,342	1915	136,941	764,475
1908	35,785	225,998	1916	155,735	922,654
1909	50,742	291,747	1917	218,828	2,287,722
1910	69,427	430,196	1918	263,817	5,465,481
1911	87,048	611,447	1919	138,290	3,525,574
1912	116,545	769,163	1920	186,778	4,718,547

(a) Statistics of U. S. Geol. Surv.

Imports.—The imports of fluorspar into the United States during 1920 amounted to 24,612 short tons, valued at $265,630; in 1919 they were 6943 short tons, valued at $107,631. The value at the foreign ports of shipment assigned to the imports for 1920 averaged $10.79 a ton; for 1919 it was $15.50 a ton. The imports for 1920 are greater than in any year since 1913, when they were 22,682 short tons.

The increase in the imports of fluorspar in 1920 can probably be attributed to the difficulty in securing supplies from American mines, due to the insufficient car supply and labor troubles, and to the easing up of the ocean-freight situation. Most of the English spar is consumed at steel works in the Lehigh and Susquehanna valleys of Pennsylvania, at which points the foreign material can be delivered at a slight advantage in price on account of a saving in railway freight charges.

According to a consumer in the Lehigh valley who uses a large quantity of fluorspar imported from England, the foreign spar purchased in 1919 averaged 75 per cent. calcium fluoride and 4 per cent. silica, and the cost delivered at its works was about $7 a ton less than the cost delivered of the domestic spar, which averaged 85 per cent. calcium fluoride and 6 per cent. silica. This consumer states that the better grades of domestic fluorspar are more efficient than the imported material

and that on a fairly even price basis the better grades of domestic spar are preferred.

A consumer in southeastern Pennsylvania who also uses considerable quantities of English fluorspar states that the material imported in 1919 averaged 83 to 87 per cent. calcium fluoride and 8 to 10 per cent. silica, and the cost delivered at its steel plant was about $21 a ton.

Small quantities of fluorspar have been imported into the United States from Canada prior to 1919, the largest being in 1918, when 913 tons was reported, practically all of which was obtained from Ontario. During 1920 the imports increased to 7068 tons, a considerable portion of which was fluorspar concentrates from the Rock Candy mill in the Similkameen district, British Columbia, which was shipped to steel plants at Gary, Ind. The following table shows the imports, by countries, for 1920.

FLUORSPAR IMPORTED INTO THE UNITED STATES IN 1920
(In short tons)

Country.	Quantity.	Value.	Average per Ton.
England	17,096	$144,142	$8.43
Canada	7,068	110,532	15.64
Germany	407	9,450	23.22
Australia	11	426	38.73
British South Africa	30	1,080	36.00
	24,612	$265,630	$10.79

FLUORSPAR IMPORTED, IN SHORT TONS (a)

	Quantity.	Value.	Average Price per Ton.
1912	26,176	$71,616	$2.74
1913	22,682	71,463	3.15
1914	10,205	38,943	3.82
1915	7,167	22,878	3.19
1916	12,323	52,976	4.38
1917	13,616	114,598	8.42
1918	12,572	169,364	13.47
1919	6,943	107,631	15.50
1920	24,612	265,630	10.79

(a) Statistics according to Bureau of Foreign and Domestic Commerce, Department of Commerce

The figures showing the imports were compiled from the records of the Bureau of Foreign and Domestic Commerce, of the Department of Commerce.

The Industry by Districts

Arizona.—It is reported that several operators in the vicinity of Dome and Sheldon have made shipments of fluorspar to California steel plants, and one operator reports having shipped a small tonnage to a copper smelter at Humboldt.

Colorado.—The principal producing districts in this State are at Wagon Wheel Gap and in the vicinity of Jamestown. The producers at Wagon Wheel Gap reported business good up to Nov. 1, 1920. The demand of the steel works at Pueblo is supplied by the Wagon Wheel Gap mine, and in addition considerable spar is shipped to midwest and eastern points.

Illinois.—The southern Illinois district makes that State by far the most important fluorspar producer, furnishing in 1920 about 64 per cent. of the total domestic production. The shipments in 1920 have been exceeded only in the two war years 1917 and 1918. The shipments in 1920 were about 120,299 short tons, valued at $3,096,767, which is an increase in quantity of 30 per cent. and in value of 27 per cent. as compared with shipments in 1919, which were 92,729 tons, valued at $2,430,361.

The most important feature of the year was the start of work on the new mill of the Hillside Fluorspar Mines near Rosiclare. This company owns the eastern extension of the Rosiclare vein adjoining the property of the Rosiclare Lead and Fluorspar Mining Co. A 6 by 20-ft. shaft was sunk to a depth of 250 ft. and the upper 170 ft. concreted down to solid rock. The shaft has two hoisting compartments and one pipe and ladderway equipped with a steel stairway. Two 3-ton skips will be used in balance. A well-equipped concrete and steel mill designed for a capacity of 25 tons of crude ore per hour, brick power, pump and hoist houses and a steel head-frame are under construction. Important features of the mill will be close sizing by trommels with separate jigging of each size, special dewatering and drying conveyors and automatic conveying of finished spar to loading bins over the railroad tracks. This will be one of the largest and most modern fluorspar mills in existence.

The Blue Diggings deposit of the Fairview Fluorspar and Lead Co. was exhausted during the year and the head works were removed. The increase in zinc sulphide, sphalerite, in the Fairview ores necessitated some changes in the mill. A new jig was installed, slightly finer grinding used, and the feed sized closer to eliminate more zinc sulphide, the specific gravity of which is close to that of fluorspar. Four new concentrating tables were added to treat the fines. During the year this company also built a plant to crush their limestone waste rock to ¼-in. size for agricultural limestone. They are planning to build a new mill in 1921 to treat their fluorspar ores high in zinc.

At the Rosiclare Lead and Fluorspar Mining Co. considerable progress was made in development work. The main shaft was sunk to 680 ft. and an ore-pocket cut on the 600-ft. level in preparation for mining on that level. The 400-ft. level of the Daisy mine, on the Daisy vein 600 ft. north of the Rosiclare vein, was opened in 15 ft. of good ore. Mining

here, however, is somewhat more difficult than on the main vein, since the walls are bad and square-set timbering must be used. This company is probably the only fluorspar company which has done diamond-drilling from underground, but the results obtained have proved the value of such work. About 3000 ft. of horizontal holes were drilled from the mine-levels during the year and two new veins were discovered. On the surface a large coal-storage basin with concrete walls was constructed, making possible the storage of large supplies of coal as insurance against a fuel shortage. No changes in milling were made, but it is planned to remodel the concentrating department during 1921. An extensive schedule of development in the form of sinking new shafts, crosscutting to new veins, etc., is also planned for this year.

Of the smaller mines in Illinois the Cave-in-Rock Fluorspar Co. and the Spar Mountain Co. near Cave-in-Rock, the Superior Fluorspar Co. near Hicks and north of Elizabethtown, the Pell Mining Co., near Rosiclare, the Pierce Fluorspar Co., near Elizabethtown, and the Diamond Fluorspar Co. near Karbers Ridge, continued shipment. The Indiana Fluorspar Co. operated a diamond drill in their main shaft, but shipped little ore. The Superior Fluorspar Co. sank a new shaft and added a new hoist to their equipment. The Southern Illinois Fluorspar Co. near Karbers Ridge, which has been doing development work during the past 2 years, sinking a shaft and running drifts, commenced mining again on Nov. 17, 1920.

Several of the fluorspar mines in this district were somewhat hampered by a strike early in the fall, some closing down entirely and others running short-handed. Gradually the men began to return to work and the mines were running about normal when the strike was called off in November.

Most of the mines in this district used to ship all their ores by river barges down the Ohio River to railroad loading points, but since a railroad was completed from Golconda to a little beyond Rosiclare in 1919, many of the mines are now able to ship directly by rail.

Kentucky.—Fluorspar is mined in two districts in Kentucky, the western Kentucky district, in the vicinity of Marion and Mexico, and the central Kentucky district, near Nicholasville. The former is by far the most important and furnished a very large proportion of the total Kentucky production in 1919 and 1920. The shipments from mines in this State during 1920 were 46,091 short tons, valued at $1,246,942, as compared with 32,386 tons, valued at $883,171, in 1919, an increase in quantity of 42 per cent. and in value of 41 per cent.

While the production from Kentucky was large during the war and is still second in importance in the United States, the situation differs from

that in Illinois since there are no very large mines and the output is maintained by many small mines, most of which are at some distance from a railroad. At the end of the war many of these mines were forced to close down, but a number were reopened late in 1919 and early in 1920. In the fall of 1920 the demand for Kentucky spar dropped off and, toward the end of the year, most of the mines were closed again. Early in December it was reported that the only large mines in operation in the western Kentucky district were the Franklin mine of the Fairview Fluorspar and Lead Co., the Mary Belle mine of the Kentucky Fluorspar Co., the Tabb mine of the West Kentucky Ore Co., the Lucile mine of the Gugenheim Mining Co., the Haffaw mine of the Aluminum Ore Co., and the Blue and Marble mine of the Keystone Fluorspar Co. Since the small size of many of the deposits does not justify the erection of efficient mills of large capacity, custom milling by one or two large centrally located mills may aid in the solution of the problems of this district. By this means a good grade of spar can be produced and a more steady production maintained. It is reported that one or two such custom mills are now in operation in the western Kentucky district.

In the western Kentucky district the operation of the Haffaw mine near Mexico, by the Aluminum Ore Co., is of interest. This mine at present is making mostly gravel spar, but experiments are being made in the mill to raise the grade of the ore mechanically to acid grade. The general practice now is to make acid grade by hand-sorting, but if this can be done mechanically costs will be greatly reduced and much material previously unsuitable will be available for acid grade.

During the winter of 1919–1920 a new working shaft 110 ft. in depth was sunk at the Big 4 mine, and by crosscutting to the La Rue vein it is reported that a very large orebody was opened.

In the central Kentucky field it was announced that the Heywood Minerals Co., Inc., with general offices at Nicholasville, Ky., had been formed and had taken over the Twin Chimney and Dean fluorspar mines near Harrodsburg, Mercer County, and the Moore mine near Nicholasville, Woodford County. A new mill was constructed with a daily capacity of 50 tons of spar.

Nevada.—The Continental Fluorspar Co., which commenced operations in the fall of 1919, reports a small production in 1920, from its mine near Beatty. The fluorspar from this State is shipped to steel plants in California.

New Hampshire.—Operations were curtailed at the Stoddard mine at Westmoreland, Cheshire County, which is operated by the American Steel & Wire Co. to supply the demand of its steel plant at Worcester, Mass.

New Mexico.—The fluorspar industry in New Mexico was very active in 1920. Before the war the production was small and intermittent and all the spar was shipped to steel mills in Colorado. In 1918, after no shipments since 1915, greater activity was shown and a production of 3437 tons valued at $64,348 was reported. Moreover, the great demand for gravel spar for steel-making and the consequent high prices made it possible to ship to the eastern steel mills. In 1919 the shipments showed a decrease to 2346 tons, valued at $37,643, but in 1920 they reached about 6353 tons, valued at $101,460, which is by far the largest ever recorded by this State. The output is obtained from Dona Ana, Sierra, Grant, and Luna counties, in the southwestern part of the State, and shipments are made to Canada, California and eastern points.

The Great Eagle fluorspar mine, 30 miles north of Lordsburg, on the Gila River, is reported to be the largest in New Mexico. This mine was sold Oct. 2 to Wentworth & Goodrich of Battle Creek, Mich., and in November work was started on a 100-ton mill. This company, which has been incorporated as the Great Eagle Fluorspar Co., has also acquired another fluorspar deposit near the southern border of New Mexico, about 25 miles north of El Paso.

Tennessee.—No production was reported from this State during 1919 and 1920, but the owners state that the mines will be reopened in 1921 if market conditions justify. A small unreported output was obtained from mines in Smith County during 1917–1918.

Utah.—The operator of the Silver Queen mine, near Delle, reports a small though increased production in 1920. The market for the output is limited to the demand of the steel works at Salt Lake City, principally on account of high freight-rates to large consumption points.

Trade Conditions

At the close of 1920 very little new business was being booked, although some of the larger producers were still running to capacity on old contracts. For most of the smaller mines the market was stagnant. While in general an optimistic view is held, especially in the west, there are several disturbing features. One is that the imports for 1920 were large and increasing toward the end of the year. While Canadian competition has been small, it will probably increase. In order to equalize the price of imported and domestic spar the principal fluorspar producers recently presented a petition to the Ways and Means Committee of the House of Representatives to increase the import tariff from the present rate of $1.50 to $5 per long ton.

Many steel producers have accumulated large stocks of fluorspar which will be used up but slowly until the present industrial depression

ends. It is also possible that many consumers will withhold contracts with the expectation of lower prices. However, no tendency toward any price reductions on gravel spar have been noted.

There seems to be a tendency, particularly among western producers, to specialize on high-grade fluorspar such as is used in the acid, glass, and enamel-ware industries. This is due, no doubt, to the apparent scarcity of spar of these grades during 1920 and to the fact that the item of freight cost is relatively lower on material of high grade. It should be remembered that the consumption of fluorspar of these grades is small in comparison with that of gravel spar and any considerable increase in the production of these grades would result in an oversupply with a consequent reduction in price.

Foreign Countries

Canada.[1]—Although occasional shipments had previously been made, the regular production of fluorspar began in 1916, and during this and the three following years the Madoc district in Ontario has been the principal source of production, which in 1920 reached a maximum at 11,229 short tons valued at $260,446, of which 3752 tons valued at $68,475 is credited to Ontario and 7477 tons valued at $191,971 to British Columbia.

The Rock Candy group situated near Grand Forks in British Columbia was opened up in 1918, and in 1919 contributed 32 per cent. of the total shipments, which were 5063 tons valued at $97,837. In 1920 British Columbia contributed over 66 per cent. of the total.

The exports of fluorspar during 1920 were 6900 tons, valued at $109,683.

Canadian steel companies use from 10,000 tons to 15,000 tons per annum. This consumption is, however, at present all in eastern Canada, and the British Columbia production in excess of the requirements at the Trial electrolytic lead refinery is finding an export market.

Germany.[2]—The largest fluorspar fields in Germany are situated in the Hartz, Upper Palatinate, Thuringian Forest, and Black Forest. The best quality is produced in the Upper Palatinate. The fluorspar found found there contains generally from 95 to 98 per cent. calcium fluoride and relatively little silica.

Most of the fluorspar in Germany is consumed at present by the iron industry. According to a rough estimate made before the war it is calculated that the quantities supplied to the individual industries are approximately as follows: iron and metal smelting industry, 79 to 84

[1] Prelim. Rept. Min. Prod. of Canada, 1920, Can. Dept. of Mines.
[2] *Comm. Rept.*, Feb. 9, 1921.

per cent.; glass industry, 10 to 15 per cent.; chemical industry, 5 per cent.; enamel industry, 5 per cent.; optical industry, 5 per cent.

Today the cheapness of extraction and milling, due to the condition of German exchange, constitutes a great encouragement for the export trade. Under present circumstances the Germans are in a position to export with profit, despite the enormous wages, freights, and cost of packing. Germany is able to offer cheaper prices than any other country.

FULLER'S EARTH

Output in 1920.—The production of fuller's earth in 1920, according to a statement made public by the United States Geological Survey, was 128,487 short tons, valued at $2,506,189, or $19.51 per ton. These amounts represent the largest output, the largest value, and the largest average price ever recorded. The output was 21 per cent. greater than in 1919; it was more than 3 times as great as in 1913 and nearly 19 times as great as in 1895, the first year of production. The value in 1920 was 25 per cent. greater than that in 1919, nearly 7 times as great as that in 1913, and 60 times as great as that in 1895. The average price per ton in 1920 increased only 4 per cent. over that in 1919.

Fuller's earth was produced in eight states in 1920; named in the order of their rank in output they were Florida, Georgia, Texas, Alabama, Nevada, Arkansas, California, and Massachusetts. Promising deposits of fuller's earth have been discovered also in Pennsylvania and Virginia. The Southern States reported 99 per cent. of the output, Florida alone reporting about 85 per cent. of the total.

Output in 1919.[1]—The output in 1919 was 106,145 short tons, valued at $1,998,829, an increase of 21,677 tons, or 26 per cent. in quantity and of $852,475, or nearly 75 per cent. in value over 1918. The increase in average price per ton was $5.26, or 39 per cent., compared with 1918. Imports also increased, though not in the same proportion as production, the increase in quantity being 10 per cent. and in value 15 per cent. Exports of fuller's earth are not separately classified by the Bureau of Foreign and Domestic Commerce, but partial returns from producers indicate that in 1919 they amounted to about 1400 short tons. On this basis the domestic earth used was about 89 per cent. of the total consumption in 1919, compared with about 87 per cent. in 1918 and about 81 per cent. in 1917.

The prospects for increased output seem good; many new developments will probably take place in the near future. This appears to be especially true of the Pacific coast, where deposits of large size and excellent quality have been found. The deposit in Ash Meadows, Nye County, Nev., near Death Valley, Calif., was developed experimentally in 1919 and, with other deposits that have been discovered in the same region, promises to be of great value. As fuller's earth is used largely in the refining of petroleum, the quantity of fuller's earth mined is naturally affected by the quantity of petroleum produced.

[1] Jefferson Middleton, *Min. Res. of the U. S.*, 1919, Part II (1921).

STATISTICS OF FULLER'S EARTH IN THE UNITED STATES (a)
(In tons of 2000 lb.)

Year.	Production.		Imports.		Year.	Production.		Imports.	
	Sh. Tons.	Value.	Sh. Tons.	Value.		Sh. Tons.	Value.	Sh. Tons.	Value.
1907.....	34,039	$323,275	14,648	$122,221	1914.....	40,981	$403,646	24,974	$195,083
1908.....	30,517	270,685	12,279	93,413	1915.....	47,901	489,219	19,441	152,493
1909.....	29,561	289,000	12,752	101,151	1916.....	67,822	706,951	15,001	139,664
1910.....	30,857	277,293	16,857	132,545	1917.....	72,567	772,087	16,994	176,417
1911.....	34,668	335,350	18,224	143,594	1918.....	84,468	1,146,354	16,920	226,235
1912.....	32,715	305,522	19,109	145,337	1919.....	106,145	1,998,829	13,873	189,711
1913.....	38,594	369,750	18,628	145,588	1920.....	128,487	2,506,189	19,235	221,893

(a) U. S. Geol. Surv.

Fuller's Earth in Georgia.[1]—Unusual activity in the fuller's earth industry of Georgia is to be recorded for 1920. Considerable money was expended in prospecting in Stewart and Decatur counties. In the latter county the Atlantic Refining Co. was successful in locating a large deposit of high-grade fuller's earth suitable for the refining of mineral oils, and the company erected a refining plant which produced its first output in October, 1920. The maximum daily production of the plant is 200 tons. The thickness of the deposit of fuller's earth now being worked varies from 3 to 7 ft.

The plant of the Georgia Reduction Co., situated on the Dublin & Savannah R.R. 14 miles south of Macon, was seriously handicapped by lack of labor and coal during the early part of the year. In the last two months, however, labor at reduced wages was plentiful and the coal supply satisfactory.

Imports.—The imports of fuller's earth, which for many years constituted the entire source of supply, also increased in quantity and value in 1920. During the war these imports naturally decreased in quantity, and with the cessation of hostilities they increased again. The imports in 1918 were about 50 per cent. of the maximum (24,977 short tons in 1914); in 1920 they were 77 per cent. of the maximum. During the war some refiners of edible oils and fats—by whom the imported fuller's earth is probably used exclusively—were unable to obtain a sufficient supply of foreign earth and were compelled to adapt domestic earth to their needs, and it may be that imports of this material will never again be so essential to the American industry.

The imports of fuller's earth in 1920 were 19,235 short tons, valued at $221,893, or $11.54 a ton. These amounts represent an increase of 39 per cent. in quantity and of 17 per cent. in value. The average price at the markets of the country from which the material was imported decreased $2.13 a ton.

[1] S. W. McCallie, State Geologist, Atlanta, Ga., *Eng. Min. Jour.*, Jan. 22, 1921.

FULLER'S EARTH IMPORTED AND ENTERED FOR CONSUMPTION IN THE UNITED STATES (a)

Year.	Unwrought or Unmanufactured.			Wrought or Manufactured.			Total.		
	Quantity (Short Tons).	Value.	Average Price per Ton.	Quantity (Short Tons).	Value. ($)	Average Price per Ton.	Quantity (Short Tons).	Value. ($)	Average Price per Ton.
1910.....	2,160	$14,399	$6.67	14,427	118,146	$8.19	16,857	132,545	$7.86
1911.....	1,881	10,877	5.78	16,343	132,717	8.12	18,224	143,594	7.88
1912.....	1,970	11,619	5.90	17,139	133,718	7.80	19,109	145,337	7.61
1913.....	1,916	12,344	6.44	16,712	133,657	8.00	18,628	146,001	7.84
1914.....	1,468	9,283	6.32	23,509	185,800	7.90	24,977	195,083	7.81
1915.....	850	5,176	6.09	18,591	147,317	7.92	19,441	152,493	7.84
1916.....	1,132	7,742	6.84	15,669	131,922	8.42	16,801	139,664	8.31
1917.....	1,441	11,718	8.13	15,553	164,699	10.58	16,994	176,417	10.38
1918.....	900	10,502	11.67	11,707	155,033	13.24	12,607	165,535	13.13
1919.....	373	4,301	11.53	13,500	185,410	13.73	13,873	189,711	13.67
1920.....	...	....	....	.....	.....	....	19,235	221,893	11.54

(a) Bureau of Foreign and Domestic Commerce.

With the exception of the Arkansas deposits all the known deposits of fuller's earth in the United States are of sedimentary origin and occur under the same conditions as any clay beds. The Massachusetts deposit is a glacial silt and is the only known glacial silt to be so classified. It is mined at Lancaster and the earth is used wholly in the place of alkali to remove surplus dye from woolen goods. The Arkansas fuller's earth is unique in that it occurs in the form of veins or dikes. Its formation is attributed to the alteration of basaltic dikes. The deposits are situated about seven miles south of Benton.[1]

The Florida deposits are mainly in Gadsden County, near Quincy, and the southern Georgia deposits are just across the State boundary from this town.

ANALYSES OF FULLER'S EARTH OF FLORIDA

Place.	SiO_2.	Al_2O_3.	Fe_2O_3.	CaO.	MgO.	H_2O	Moisture.
Hymeson mine ..	59.00	15.05	2.95	0.20	3.70	11.40	7.80
McPhaul mine...	58.50	14.30	2.10	1.30	6.50	9.50	7.0
McPhaul mine...	62.85	15.36	2.25	1.39	6.98	10.20	....

Great Britain.[2]—England was formerly the chief producer of fuller's earth, and exported it in large quantities. Deposits have been worked in Great Britain in a number of places, but at the present time the largest works is situated near Reigate, Surrey, where the large quarry owned by the Fuller's Earth Union, Ltd., employs upwards of 45 men. The quarry of the Surrey Fuller's Earth Co., Ltd., at Nutfield in the same district, is next in importance, and there are three mines in active operation at the present time in the same neighborhood.

[1] "Fuller's Earth." Imperial Mineral Resources Bureau, London.
[2] *Loc. cit.*

The earth is found in strata of Cretaceous age. The fuller's earth bed sometimes reaches a thickness of 12 ft., and, as a rule, the upper portion is oxidized to a brownish color by the action of percolating water, the lower portion being blue.

In Somerset fuller's earth has been worked at a number of places in the vicinity of Bath. It is found overlying the Inferior Oolite and is covered by the Great Oolite. The limestones of the Inferior Oolite contain fuller's earth in the cavities.

Other notable deposits of fuller's earth include those of Woburn Sands, in Bedfordshire. The evidence of borings and sinkings indicates that these are co-extensive with the Oxford clay. A superior quality of fuller's earth is procured from the Lower Greensand at Aspley Heath, Bedfordshire. The water thrown out by this formation is very soft and pure, and blocks of the earth have on this account been used for the purpose of purifying water in wells.

Following are the outputs of fuller's earth in Great Britain in recent years:

	Long Tons.		Long Tons.
1913	31,609	1917	27,916
1914	37,862	1918	23,290
1915	29,298	1919	24 785
1916	29,106	1920	28,,906

India.[1]—The statistics of Indian fuller's earth and similar clays are incomplete. The mineral is probably obtained in small quantities at numerous localities. It is used for the washing of clothes, and constitutes the principal part of the various edible earths which are sold in the bazaars. The earth-eating habit is prevalent throughout India, Burma and the Shan States.

[1] *Loc. cit.*

GOLD AND SILVER

By M. W. von Bernewitz

Introductory.—The world's maximum production of gold was in 1912, when it amounted to $474,322,000; the best year for silver was 1911, the total being 253,000,000 oz. On account of a general decline, but largely due to the Mexican situation, there was a fall in output until 1914, when the respective totals were $439,000,000 and 160,000,000 oz. In 1915, due to greater demand for the precious metals, and an abnormal output of base metals, which contribute approximately 10 per cent. of the gold and 70 per cent. of the silver, the yields rose to $470,466,000 and 184,000,000 oz. Since then production has fairly tumbled to the $337,000,000 gold and 171,000,000 oz. of silver in 1920. During the period 1915–1920 United States gold fell off 50 per cent., Russia (Siberia), 60 per cent., Australia, 27 per cent., and the Transvaal 20 per cent., to mention the principal contributors. The whole world's output dropped 31 per cent. Mexico was the only country that showed a real net increase, the gain being nearly 150 per cent. for the 5-year period; yet it has another 80 per cent. to go before it equals its record of 1910. As to silver, America accounts for a 30-per cent. decline, Canada 50 per cent., and Australasia 60 per cent. Mexico shows another gain, amounting to 55 per cent., but it has another 50 per cent. to go before it reaches the record of 1911. The world's decrease for the period was only 10 per cent.; but from 1911 the falling-off was 37 per cent. In Mineral Industry for 1919 it was remarked in this chapter that the abnormal conditions pertaining to the period 1914–1919 were accentuated during the last year, and copper, lead, and zinc mines throughout the world were operating at low capacity. This is also true for 1920, although it might be said that base-metal production in North and South America at least pretty well held its own during the year, and the outputs were really normal, that is, when compared with the year 1913. The war years were abnormal, and therefore are hardly comparable. Accordingly, we find in the United States that the silver output was almost the same as in 1919, 19,000,000 oz. less than in the abnormal year of 1915, and equal to the output of the normal year 1910. Gold, on the other hand, has been hard hit, production being nearly 2,000,000 oz. less in 1920 than in 1913.

This situation was briefly analyzed by H. N. Lawrie,[1] economist for the American Mining Congress at Washington, D. C. The causes are well known, and have been discussed frequently; they resulted in the Mc-

[1] *Eng. Min. Jour.*, **111**, 142 (1921).

Fadden Bill (known as H. R. 13201) being introduced into Congress in March, 1920.

Gold

In his "Safeguard the Gold Standard," H. N. Lawrie[1] stated that the McFadden Bill proposes in effect (1) the collection of an excise tax upon all gold articles of domestic or foreign manufacture sold in the United States, this tax to be at the rate of $10 per oz. of gold contained; (2) to pay a premium to the producers of new gold in the United States and its possessions, this premium to be at the rate of $10 per oz. of such gold delivered to the Mint; and (3), this tax and premium to be in effect for 5 years. The Bill proposes nothing that would interfere with the free flow of gold, or change its price. The Mint would continue to pay $20.67 per oz. for all gold offered, and the purchaser from the Mint would continue to buy freely at that price. The manufacturer of gold has in effect been receiving a subsidy, as he is enabled to buy the metal at the fixed pre-war price, while the price of everything else, not excepting that of jewelry, has increased or multiplied. The proposed tax is a luxury tax, and does not fall on the general public. During 1910, gold used in manufactures and the arts was valued at $41,787,000; in 1915, $57,820,000; and in 1919, $75,490,000. Compare this with the production for those years. In 5 years, 14,617,000 oz. of the 17,165,000 oz. produced in America has been used in the arts. And considering the world at large, on account of the diversion for the last two years of newly-mined gold into industry and the Orient, the amount of such gold available for monetary purposes has been reduced from $250,000,000 or more per annum to less than $60,000,000 during 1919 and 1920. In 1914, the United States had $1,056,000,000 of paper money in circulation, and $2,299,454,000 of gold about that time, but in 1920 it had $4,640,000,000 of paper and $2,761,339,000 of gold. The enactment of the McFadden Bill, according to Mr. Lawrie, should increase the gold output; will produce benefits to the Nation at large, immeasurably greater than its cost; and finally will safeguard and strengthen the gold standard.

The question of the constitutionality of the proposed gold excise bill was investigated in January, 1921, and the bill has been declared constitutional.

When Congress adjourned on Mar. 3, 1921, the McFadden Bill had failed to pass; therefore it was re-introduced at the next session as H. R. 5025, and at the middle of 1921 was being considered by the Treasury Department.

The Federal Treasury Department under the last Administration was opposed to the bonus. Secretary Houston in 1919 stated that the

[1] Bull. Am. Min. Congress, Jan., 1921.

GOLD AND SILVER PRODUCTION OF THE WORLD, 1493–1850
According to Dr. Adolph Soetbeer

Period.	Estimated Production in Kilograms.		Ratio of Silver to Gold. Weight.	Ratio of Gold to Silver. Value.	Period.	Estimated Production in Kilograms.		Ratio of Silver to Gold. Weight.	Ratio of Gold to Silver. Value.
	Gold.	Silver.				Gold.	Silver.		
1493–1520	162,400	1,316,000	8.1	10.75	1701–1720	256,400	7,112,000	27.7	15.21
1521–1544	171,840	2,164,800	12.6	11.25	1721–1740	381,600	8,624,000	22.6	15.08
1545–1560	136,160	4,985,600	36.6	11.30	1740–1760	492,200	10,662,900	21.7	14.75
1561–1580	136,800	5,990,000	43.8	11.50	1761–1780	414,100	13,054,800	31.5	14.73
1581–1600	147,600	8,378,000	56.8	11.80	1781–1800	355,800	17,581,200	49.4	15.09
1601–1620	170,400	8,458,000	49.6	12.25	1801–1810	177,780	8,941,500	50.3	15.61
1621–1640	166,000	7,872,000	47.4	14.00	1811–1820	114,450	5,407,700	47.2	15.51
1641–1660	175,400	7,326,000	41.8	14.50	1821–1830	142,160	4,605,600	32.4	15.80
1661–1680	185,200	6,740,000	36.4	15.00	1831–1840	202,890	5,964,500	29.4	15.75
1681–1700	215,300	6,838,000	31.8	14.97	1841–1850	547,590	7,804,150	14.3	15.83

GOLD PRODUCTION OF THE WORLD, 1851–1920

Year.	Value.	Year.	Value	Year.	Value.	Year.	Value.
1851...	$67,600,000	1871...	$107,000,000	1891 ..	$130,650,000	1911...	$464,346,495
1852....	132,800,000	1872...	99,600,000	1892...	146,292,600	1912...	474,322,664
1853....	155,500,000	1873...	96,200,000	1893...	158,437,551	1913...	462,669,558
1854....	127,500,000	1874...	90,800,000	1894...	182,509,283	1914...	439,078,260
1855....	135,100,000	1875...	97,500,000	1895...	198,995,741	1915...	470,466,200
1856....	147,600,000	1876 ..	103,700,000	1896...	211,242,081	1916...	454,176,500
1857....	133,300,000	1877...	114,000,000	1897...	237,833,984	1917...	419,422,000
1858....	124,700,000	1878...	119,000,000	1898...	287,327,833	1918...	380,924,000
1859....	124,900,000	1879...	109,000,000	1899...	311,505,947	1919...	365,166,000
1860....	119,300,000	1880...	106,600,000	1900...	258,829,703	1920...	342,000,000[1]
1861....	113,800,000	1881...	103,102,000	1901...	260,877,429	.....	.....
1862....	107,800,000	1882...	102,000,000	1902...	298,812,493	.....	.....
1863....	107,000,000	1883...	95,400,000	1903...	329,475,401	.....	.....
1864....	113,000,000	1884...	101,700,000	1904...	349,088,293	.....	.....
1865....	120,200,000	1885...	108,400,000	1905...	378,411,754	.....	.....
1866....	121,000,000	1886...	106,000,000	1906...	405,551,022	.....	.....
1867....	104,000,000	1887...	105,775,000	1907...	416,101,396	.....	.....
1868....	109,700,000	1888...	110,197,000	1908...	443,355,856	.....	.....
1869....	106,200,000	1889 ..	123,489,000	1909...	458,424,058	.....	.....
1870....	106,900,000	1890...	118,848,700	1910...	453,766,523	.....	.....

Recent figures from the U. S. Bureau of the Mint. [1] Estimated.

Treasury was opposed to subsidies in general, and was particularly opposed to subsidizing the gold-mining industry. He believed that the gold miners would in the long run benefit with the rest of the community from the ability of this country to maintain itself on a gold basis. This attitude was based upon a previous report, which urged that no relief was necessary on account of returning normal conditions. However, prices afterwards increased, and gold output has diminished, indicating an error in judgment.

It has been reported that the American Bankers' Association was against the McFadden Bill, but this needs to be explained, as was done by J. F. Callbreath at the annual conference of the American Mining Congress at Denver in November, 1920. Briefly, the Bankers' Association held two meetings, and passed a resolution unquestionably favoring aid by the Federal Government in stimulation of the gold-mining industry. Both meetings recognized that gold is the basis of credit, and we

could not have too much gold. America, having one-third of the world's gold supply, maintains its currency at par. England, with the next largest amount, comes nearer par than other countries; and just in proportion to the amount of gold that foreign countries own, so in that proportion is their credit and currency maintained in value. After these two meetings of the Association, consideration was focused on the McFadden Bill in its present form. Following this there was some inside objection, resulting in another committee bringing in an adverse report. This was brought before the Association early in November, 1920, but was not approved. It was referred to another committee on policy, and so, instead of the Bankers being opposed to the bill, they refused to approve of an adverse report. Therefore, probably they will be an aid in securing enactment of the Bill.

Unless constructive aid is provided without delay, the gold-mining industry of this country will be completely shut down, according to Louis T. McFadden, sponsor for the bonus bill under his name, when interviewed on Oct. 7, 1920. He said:

> If the matter is delayed, it will take years to develop a normal output of gold at a very much greater expense. To allow the gold mines of the United States to cave in and fill with water entails a waste of developed gold resources, which in a most critical hour of financial need will cause want. No argument can be made in favor of waste. The time to act is now, before the industry is shut down.

GOLD PRODUCTION OF THE WORLD, BY COUNTRIES

	1917.	1918.	1919.	1920.[1]
Transvaal	$186,426,600	$174,025,500	$172,230,500	$165,000,000
Rhodesia	17,245,100	13,051,300	12,267,400	11,500,000
West Africa	7,610,700	6,803,000	6,081,500	4,400,000
Congo, Madagascar, etc	3,021,900	3,196,000	3,200,900	3,000,000
Total Africa	$214,304,300	$197,394,700	$193,780,300	$183,500,000
United States	$83,750,700	$68,646,700	$60,333,400	$49,509,000
Mexico	9,000,000	16,824,000	15,248,500	15,500,000
Canada	15,273,000	14,687,900	15,858,700	16,000,000
Central America	3,122,000	3,400,000	3,300,000	3,500,000
Total North America	$111,145,700	$103,559,300	$94,740,400	$84,509,000
Russia, including Siberia	$18,000,000	$12,000,000	$8,000,000	$8,000,000
France	700,000	200,000	151,000	150,000
Other Europe	165,700	212,800	651,000	500,000
Total Europe	$18,865,700	$12,712,800	$8,802,000	$8,650,000
British India	$10,812,800	$10,028,200	$10,486,000	$[illegible],100,000
British and Dutch E. Indies	2,853,700	2,571,400	1,850,000	1,800,000
Japan and Chosen	8,147,500	8,405,900	7,604,000	7,600,000
China and others	4,836,700	4,509,000	3,680,000	3,600,000
Total Asia, not inc. Siberia	$26,783,700	$25,514,500	$23,620,000	$22,100,000
South America	$13,924,600	$12,795,000	$14,112,300	$15,000,000
Australasia	34,398,100	29,268,600	26,112,200	24,000,000
Total for world	$419,422,100	$380,924,700	$361,167,200	$337,759,000

[1] Preliminary estimates.

It appears that the French Government imposes a heavy tax on gold used in the arts.

In his analysis of world debts and paper currency, O. P. Austin, statistician for the National City Bank of New York, made the following statements, which were reprinted in the *Congressional Record* for Jan. 17, 1921:

"With the enormous increase in paper currency and the marked fall-off in gold production, the ratio of gold to notes has fallen from 66 per cent. to less than 10 per cent. World paper currency is now 11 times as much as at the beginning of the war and the world demanding increased quantities of the yellow metal for the arts and industries, the available supply as a backing of 'reserve' bears a constantly diminishing ratio to the note circulation."

During the convention of the American Mining Congress at Denver, Nov. 15–20, 1920, gold mining and flotation were two of the main topics. The principal speakers were W. J. Loring (President) and Fletcher Hamilton, of California; H. N. Lawrie, of the precious-metal department of this Congress; G. E. Collins, of Colorado; Milnor Roberts, of Washington, who spoke on Alaskan conditions; H. M. Parks, of Oregon; B. C. Yates, of South Dakota; and W. B. Phelps, of Arizona. All are strongly in favor of the bonus bill. Mr. Lawrie presented some interesting tabulated "gold facts" and graphics of the subsidy paid by producers—based on production and decline in purchasing power of the dollar—and a curve showing the decline in purchasing power of the dollar. The lengthy discussions and prepared papers are to be found in the Proceedings of the Mining Congress for 1920.

Judging by the public utterances of responsible gold-mining men and others throughout the country, the feeling about the gold bill is fairly evenly balanced—as many against as for it. Space forbids printing even brief abstracts of these opinions, which were expressed at various times during 1920.

While American gold producers have been clamoring for a bonus of $10 an ounce, companies operating in the British Empire have been realizing large premiums on selling their product in the open market. Yet, as many thought, the additional price received was not profit, but simply a higher value due to the low point of the pound sterling. When exchange was low, the price of gold rose; when higher, the price dropped. In the words of Francis A. Govett, a director of the Ivanhoe Gold Corporation, a famous Australian producer, "The gold premium in any country is, of course, roughly the equivalent of the highest measure of adverse exchange against that country. Gold represents the parity of exchange, and the more adverse it is the higher the premium which must be paid for gold."

Last year, 1920, was the first year during which the price of gold moved almost every day, and also commanded continuously a very heavy premium upon that paid by the Royal Mint—77s. 10·5d. per standard, or 84s. 11·45d. per fine ounce. A quotation had been fixed per fine ounce daily (Saturdays and holidays excepted) since Sept. 12, 1919; it applied only to African gold for which the Treasury was prepared to grant an export license. The price on the first working day of the year, Jan. 2, was 109s.—that is to say, at a premium of about 28·5 per cent. on the Bank of England buying price, 77s. 9d. per standard (84s. 9·81d. per fine ounce). The price on the last working day was 116s. 1d. (36.8 per cent. premium). The lowest price, 102s. 7d. (20·9 per cent. premium) was touched on April 9; the highest, 127s. 4d. (50·1 per cent. premium) on Feb. 5. The average for 1920 was 112s. 11.52d. (33.2 per cent. premium), according to Samuel Montagu & Co. of London. By February, 1921, the price had receded to 106s. per oz.

In Germany, where the mint price of fine gold is normally 1395 marks per kilo, the metal in 1920 was being sold at 67,000 marks, due to depreciated exchange.

According to Henry Strakosch, managing director of the Union Corporation, a holding company for Transvaal and other companies, at a sitting of the Brussels Conference in 1920, an international agreement to stabilize the value of gold at its present level is neither practicable nor desirable, and he maintains that economy in gold for monetary purposes will only be possible when confidence in the methods of money and credit creation has been restored. Regarding future gold production, Mr. Strakosch said that there would be another decline in 1920 and 1921, and from thence onward the output would more or less steadily recede.

In spite of adverse conditions, the Canadian output of gold is increasing, especially so in Ontario, and the industry, to quote W. R. Rogers, statistician of the Ontario Department of Mines, "does not require the stimulus of a McFadden Bill, as proposed in the United States, which aims artificially to bolster up a languishing industry."

The following movements of gold are from the monthly summary of foreign commerce of the United States, issued by the Department of Commerce at Washington.

Year.	Imports.	Exports.
1911	$57,445,184	$37,183,074
1912	66,548,772	47,424,842
1913	63,704,832	91,798,610
1914	57,387,741	222,616,156
1915	451,954,590	31,425,918
1916	685,990,234	155,792,927
1917	552,454,374	371,883,884
1918	62,042,748	41,069,818
1919	76,534,046	368,185,248
1920	428,703,506	322,091,208

Of the 1920 imports, $107,000,000 had previously been held in the Bank of England as a part of the gold reserve of the Federal Reserve Banks.

Of the gold imports last year, $274,982,197 was from Great Britain;

$48,738,524 from France; $34,196,287 from Canada; $30,191,910 from Hongkong; and $9,489,812 from Colombia. Of the exports, $101,299,476 was to Japan; $89,995,000 to Argentina; $31,496,872 to Hongkong; $28,286,750 to China; $18,171,684 to Mexico; $12,850,000 to Uruguay; $12,085,105 to Dutch East Indies; and $6,752,549 to India.

The stock of gold in the United States at the beginning of 1921 amounted to $2,784,834,427, a decrease of $2,879,879 during the year. America holds about 35 per cent. of the world's total.

Regarding 1921, American bankers expect a continuance of gold imports from Africa, via London, and possibly for the next three years. Shipments are being received from India. It is pointed out[1] that purchase of this metal is based on sterling-exchange operations, and no rise in exchange rate that might cause a cessation of import movement is expected within the next 12 months at least. Bankers say there is only one possibility of exchange turning against this country in the near future —that the huge balance due this country from Europe might be funded into a long time loan. In that case, if current movements of goods between United States and European countries should show balances unfavorable to the United States, it would result in cessation of gold imports.

A curious feature in gold movements last year was that of metal from Russia, styled by British and American Governments as "Soviet gold." Samuel Montagu & Co. of London said:

> During the latter part of the year there have been earnest but largely ineffectual efforts on the part of the Soviet Government of Russia to dispose of gold—which erstwhile figured in the reserves against the Russian State Bank Notes—as part payment for goods in Europe and America. The strong attitude of France, in threatening to place an embargo upon what she regards as part security for heavy sums advanced to the Imperial Russian Government, rendered the process difficult of accomplishment, though a considerable quantity was lodged in Sweden. Accustomed as the London market has always been to deal in gold by the ounce, the offer of gold in terms of a dozen tons at a time has been a quaint innovation.

Late in 1920, a large quantity (several millions of dollars) of Russian gold went abegging in New York; no banks nor the United States Government would touch it. The Mints and Assay Offices had strict instructions by the director, Raymond T. Baker, to refuse all gold known to be of Soviet origin, no matter by whom tendered. An immense quantity of gold was exported from Russia during the year, the total approaching 700,000,000 rubles, say 17,500,000 oz. at normal exchange.

Exports and imports of gold in Great Britain during 1920 are as follows:

[1] *Boston News Bureau*, Jan., 1921.

	Exports.	Imports.
Russia	.....	£ 1,965,095
Sweden	£ 107,252	894,275
Netherlands	4,635	201,049
France	474,888	6,710,799
Switzerland	750,250	.....
Spain and Canaries	356,115	193,933
West Africa	68,322	1,026,207
Java and other Dutch possessions	384,000	.....
United States	52,833,423	10,954
Argentina, Uruguay and Paraguay	4,237,038	.....
Other South American countries	1,498,748	.....
Egypt	745,560	74,900
Rhodesia	.....	2,348,637
Cape Colony	3,610,661	.....
Transvaal	.....	36,314,286
British India	23,629,272	270,500
Straits Settlements	3,727,670	69,670
New Zealand	265	351,521
Other countries	137,029	246,457

A large proportion of the above excess of exports over imports during 1920 consisted of gold which was hitherto held in London on account of the United States Federal Reserve system and was transferred to the United States.

Silver

It is probably not saying too much when it is remarked that the Annual Bullion Letter of Samuel Montagu & Co. of London contains the most reliable data published on silver. That for 1920 is given herewith (1d. or penny = 2 cts. normal exchange; British quotations for silver 925 fine, American for 1000 fine):

The market at the commencement of the year was in a remarkably firm condition. The price in London on the second of January—the first working day—was quoted at 75⅞d. for cash and 74d. for two months' delivery. The British market was well supplied with demonetized silver—mostly German marks—and quotations usually ruled below those current in America. China continued to draw silver freely from London and the United States, whence as much as ten million taels (1 tael = about 1.2 oz.) worth of dollars and bars were despatched in one consignment. The strength of the Chinese demand arose largely from the discredit into which the paper money (hitherto freely current in Asia) had fallen. The trend of prices was almost persistently upward. Each week, until that ending Feb. 12, recorded an advance. The highest price of the year—indeed the highest since statistics have been systematically recorded—was reached on Feb. 11, namely, 89½d. for cash. This remarkable quotation is more than four times the record low figure of 21 11/16d. touched in 1902.

The phenomenally high price of silver impelled the Indian Government on Feb. 2 to take several important steps in dealing with the currency situation, so as to avoid the necessity of coining silver rupees at a loss. Imported gold was to be acquired on the basis of 10 rupees to the sovereign (£1). The prohibition on the import of silver, which had been in force since September, 1917, and that against using silver coin otherwise than as a currency, were removed. At the same time private imports of silver were again allowed and the import duty entirely abolished. The prohibition against the export of silver was maintained until June 21.

The imminent approach of the Chinese New Year (Feb. 20) and a strong recovery of American exchange brought about a powerful reaction, in the course of which two records were made, the largest known movement in one day, and the greatest difference

between the quotations for cash or forward delivery. The price for forward delivery fell no less than 5¾d. on Feb. 13, to 79¾d., and a discount of 5d. was registered on delivery as compared with the quotation for cash. As a record movement, however, this was subsequently surpassed. The fall was accentuated by sales on account of China. So strong, however, were the influences at work that the rate for forward delivery recovered 3½d., namely to 83¼d., within four days.

The very high quotations naturally caused the Government to take precautions against the risk of the subsidiary coins of the United Kingdom being turned into bullion, the Royal Mint issuing such coin on the basis of 66d. per standard ounce of contents. The illegal profit at 89½d. would have been over 33 per cent. Powers were granted by Parliament for the reduction of the quality of silver coinage in the United Kingdom and elsewhere in the British Empire where similar sterling coin circulates, from 925 to 500 parts in the 1000 fine, thus increasing the mintage value of the silver coinage to 122.1d. per standard ounce. That the United Kingdom—so conservative in matters of currency—should take this step was clear indication that token coin silver had entered upon a new phase of considerable moment to its future prospects. Holland, equally tenacious of old customs, reduced the quality of its silver coin, and several other nations took somewhat similar steps. In these circumstances, it is hardly likely that Germany, or the other nations lately allied with her, will return to the old fineness, when and if they make use of silver for the coinage of subsidiary money. This drastic action of the Government in regard to the silver coinage suggested that the Mint would not be likely to purchase silver for a considerable period. A pound's worth of silver coin of the old quality (925 fine) when coined into new silver coin (500 fine) is sufficient to provide legal tender to the extent of £1 17s. The new coins made their appearance in December. The moral effect of this important change was driven home by very large sales of demonetized coin from the Continent, and by heavy realization of the weightier descriptions of manufactured silver in jeweler's stocks and in private hands. Many remarkable examples of early Victorian taste had thus to make a fiery exit from a world that had hitherto tolerated their existence.

The rise in the value of silver had been assisted by the depreciation of the pound sterling. A decided improvement in this respect, recorded in the early part of March, led to a very sharp fall on the 5th, when the quotation fell 6⅛d. for cash—from 84d. to 77⅞d.—and that for two months' delivery 5⅞d.—from 83⅝d. to 77¾d.,—constituting a fresh record movement in one day. By the 17th the quotations had dropped to 65¾d. and 66d. respectively. The fall awakened such a keen demand in the East that a powerful reaction carried prices in five days to 77d. and 76¾d. respectively; the mark, however, was overshot, and in two days both quotations had receded to 71½d.

The high level of quotations, assisted by the appreciation of the pound sterling in nearly all Continental countries, attracted great quantities of silver currency to London for realization as bullion. As a consequence, currency media became very scarce. In France, for instance, Chambers of Commerce and tradesmen issued card or paper coupons, and customers at Parisian shops had often to be content to receive as small change transparent envelopes containing postage stamps. In Germany and elsewhere matters were much much worse. The abundant supplies of demonetized coin from these sources enabled the London market to move independently from that in the United States, and by its elasticity to govern to a large extent United States quotations for the metal. The large and constant arrivals of melted coin in London put a considerable strain upon refining resources, although the equipment hitherto had been more than sufficient to deal with refinable supplies. It became necessary to sell such

silver for two months' delivery, by which time refiners hoped to return the fine contents of refinable bullion. As a consequence silver for forward delivery went to a heavy discount in April—on several occasions to the extent of 3d. On the 17th of that month a discount of 3 5/8d. was recorded owing to an insistent demand from the Indian Bazaars for prompt shipment. On the 10th of April, exceptionally heavy accumulations of silver, namely about 44,700,000 oz. in sycee (60-oz. bars) were reported in Shanghai, 23,300,000 dollars (Chinese), and 40 lacs (1 lac = $33,000) of silver bars, and United States dollars. The last mentioned item indicates that the size of the stock was largely owing to the fact that American Banks trading in China had a quantity of United States silver coin specially placed at their disposal. After the above date, Shanghai stocks commenced to contract.

The American quotation for silver stood at the beginning of the year, and for about five months thereafter, above the dollar an ounce at which the Director of the U. S. Mint was instructed to re-purchase the silver dollars sold under the Pittman Act. As the American price commenced to fall, and to approximate 100 cts., the market waited with interest to see whether the Mint would buy at once or defer taking action, as possibly it was entitled to do. Meanwhile, during May the price in London kept at a level averaging rather under 60d. the ounce. When the American price dipped at last below the dollar point, and the Mint failed to purchase, the London price fell away rapidly, until, on June 15, 44d. was recorded for cash and 44 1/4d. for two months' delivery.

In the third week of June, the U. S. Mint began to accept tenders made under the Pittman Act. This action imparted confidence to the market generally and quotations promptly recovered to the neighborhood of 50d. The delay in purchasing appeared to be owing to the difficulty of proving satisfactorily that the silver tendered was of American origin. Ultimately a suitable form of certificate was formulated, subject to which the Mint was prepared to accept silver which had been delivered by American mines to domestic refineries after Jan. 17, 1920. Silver interests in the United States pinned great hopes upon the Mint purchases, and expected for a lengthened period a stable or even a strong market. The immediate effect was substantial; the withdrawal of a quarter of the world's production from competition in the world markets could hardly be otherwise. Optimistic views as to the future were held by American Banks operating in China, doubtless stimulated by the bullish anticipations prevalent in silver circles at their home base.

The quotation ranged around 52d. and 53d. until July 21, when a keen demand set in from the Indian Bazaars and carried the price to a much higher level, in the course of which 63 3/4d. was reached on Aug. 20. Some portion of the rise must be attributed to the weakness of sterling in America, thus making the parity with the New York quotation much higher. For instance, when the price was quoted 55 1/4d. on July 21, the American exchange was 3.83, whilst on Aug. 20 it was 3.58. Thus the exchange was responsible for 3.6d. of the increase between the two prices.

A remarkable result of the buying under the Pittman Act was that two quotations became necessary in the United States, one for domestic and one for foreign silver. The former quoted invariably 99 1/2 cts., unless the market demand carried foreign silver above that figure. Purchases under the Pittman Act were continued until inquiry from China became particularly intense toward the end of August, and drove the American value of the metal again well over the dollar point. The price of silver, however, failed to advance beyond 63 3/4d., being checked by the possibility, ultimately an actuality, of silver rupees being exported from India as soon as their external bullion value exceeded their value as currency. All legal obstacles to this being done had

been removed by the abrogation of the prohibition against using gold or silver coins otherwise than as currency (when the new gold equivalent of the rupee was fixed in February, 1920), and of that against export of coin or bullion on June 21, 1920. The likelihood of silver rupees being exported was especially interesting, in view of the extreme difficulty which the Indian Government had found in providing sufficient material for silver rupees during the war. Before rupees could be marketed in London profitably, the price had to be sufficiently high to cover the cost of transmission, refining, etc., and loss of interest incurrable until the transaction became complete. The combined result of Chinese demand, some Indian Bazaar bear sales, and a rather immobile American exchange, kept the quotation at about 60d. until the end of September. Inquiry for China was largely dominated by speculative influences, for Chinese export trade was mostly at a standstill. In these circumstances, it was surprising how the price was maintained so long. India was more a seller than a buyer. The Continent sent a constant, though less insistent, stream of supplies. Hence China alone had to shoulder the burden.

Naturally, failing supplies of American origin, the Mexican output became of supreme interest. A change of Government was made in Mexico during the early summer and proved advantageous to that country, where civil war had held sway for many years. Security of life and property began to be assured, and the mining industry was not slow to profit by the change. The output for 1920 may easily prove a record, though even 80,000,000 oz. by no means represents the mining possibilities of that country. A certain amount, though not a large proportion, of this year's Mexican output has been minted, mostly for payment of the miners' wages, leaving a considerable balance of perhaps 60,000,000 oz. for export in the form of bullion or ore.

The output of the United States is disappointing. Labor troubles, high cost of plant, and falling prices for the base metals will tend to reduce the total. This is not of so much moment as usual, owing to the purchases for the Mint under the Pittman Act. The smaller the American production, however, the longer will be the period required to replace the 207,000,000 oz. of melted dollars sold to India, provided, of course, the Act continues to be operative.

The tendency of the market from the beginning of October was dull, and prices drooped by the middle of the month to about 53d. The Indian monsoon proved much below the normal, and the Indian bazaars covered with profit the bear sales that they had previously made. Chinese export trade remained particularly poor, and most of the silver business done on China account continued to be speculative. Not infrequently, however, when the market became disposed to give way, a measure of support came from the United States. This did not prevent the difference between the American quotation for domestic and foreign silver becoming wide—20 per cent. or more separating the two. The cash price kept above 50d. in London until Nov. 19.

From the date last mentioned prices rapidly fell away, owing to ample supplies of demonetized metal, Indian bear selling, and only reluctant support from China. By the last day of November, 43⅞d. was recorded for cash and 44⅛d. for forward delivery. Famine conditions in China, extending over four important provinces, became a disquieting factor, and a prohibition against the export of certain foodstuffs from China was announced as from Jan. 1, 1921. After hesitating a while about 44d., the price made a further sharp decline to 38⅞d. for cash and 39d. for two months on Dec. 10. This was followed by fluctuations which ultimately left the price a few pence higher. The cash quotation at the close of the year—40⅞d.—was only 54 per cent. of the price fixed at the beginning.

Owing to wide fluctuations in the value of silver, Chinese and Indian exchange

quotations varied greatly at different periods of the year. On Feb. 9 the Shanghai tael was quoted officially at 9s. 3d.—a record figure—while on Dec. 11 it had fallen to 3s. 10½d. The rupee also created a record on Feb. 12 by touching 2s. 9¾d; on Dec. 8, it was only worth 1s. 4¾d.

The amount of silver imported by China during 1920 has been very large—about 70,000,000 oz. from San Francisco and 20,000,000 oz. from London. The stock at Shanghai was about twice that held towards the close of 1919, and the interior of China is now well provided with the metal. The Statistical Department of the Chinese Customs regarded the trade of 1919 as a record.

A good deal of misconception outside India as to the rupee problem arises from overlooking the fact that the natives of India regard the question as one of bullion rather than of currency, and choose to set their own ratio between currency composed of gold and of silver. In other words, the two precious metals are looked upon as commodities, the imprint of a die being but an official certificate as to the contents. The Indian Government during the year clearly endorsed the native point of view by removing the prohibition against using gold and silver coin otherwise than as currency—thus conferring a privilege not enjoyed in the United Kingdom. Gold and silver coins do not change hands in India to anything like the extent that they do in Western countries. They are obviously more treasured than current. The extent of banking facilities available for the people of India concerns closely the question as to what proportion of the world's production of the precious metals is likely to be absorbed by that country. Industrial prosperity and longseated custom as to the disposal of accumulated wealth certainly are most important factors. Nevertheless the people of India cannot be expected to make investments unless safe methods of disposing of their funds are readily accessible. The world as a whole would have good reason to welcome the return of the price of silver to a pre-war level. The persistent advance in the price of this metal had much to do with the increase in the prices of commodities, the reason being that the Allies had to depend so largely upon the products of the East, chiefly from India, with whom the world balance of trade has always been—unless the monsoon proved a failure—heavily in her favor. Wheat, rice and beans, jute, cotton, hides and skins, figure largely in the useful goods which come from India and China. It was the rise in the cost of such items as these which stimulated that of other commodities in the markets of the world.

When the constant realization of European silver coin is added to the material from mines, the available supplies in 1920 will probably exceed those of the record year 1911. Judging from the congestion of refineries, the amount of demonetized coin dealt with in 1920 was not less than 40 or 50 million ounces. The output of silver is not likely to decrease to any considerable extent, unless affairs in Mexico again become unsettled. American production may decline while the prices of the base metals, which mainly yield the silver, remain low, but new discoveries in the Yukon may more than counterbalance any reduction in the American and Ontario contributions to the world total. An increase in the Burma output is certain, and probably appreciable. The inquiry for silver cannot be expected to be so keen. The Continent is a seller of coin, not a buyer for coinage. Economy is the cry of the day, and taxation is cutting at the root of luxury expenditure. Hence, plate and jewelry will be less in request. The requirements of India are doubtful. A good monsoon would stimulate demand, especially after the poor imports of 1920; but the country is well stocked with precious metal, and coinage is out of the question. The prospect of Chinese demand is also uncertain. So much depends upon the power of China to export goods, and the ability of Europe to pay for them. It can be taken for granted, however, that the

interior of China is unusually well stocked with silver, and that confidence is being restored in official issues of notes.

When the pros and cons are weighed, too much importance should not be put upon the rumors current that the Pittman Act will be abrogated. Any attempt at

SILVER PRODUCTION OF THE WORLD, BY COUNTRIES
(In Troy Ounces, Fine Silver)

	1917.	1918.	1919.	1920.[1]
United States	71,740,000	67,810,100	56,682,400	56,564,000
Canada	22,221,300	21,284,600	15,675,100	13,500,000
Mexico	35,000,000	62,517,000	62,682,000	66,200,000
Central America	2,369,500	2,900,000	2,800,000	3,000,000
South America	15,451,300	15,561,000	14,713,200	15,500,000
Total America	146,782,100	170,072,700	152,552,700	154,764,000
British India	275,000	270,000	192,600	180,000
Burma	1,793,700	1,970,500	1,973,000	2,000,000
Japan and Chosen	7,138,200	6,626,400	4,845,000	4,500,000
China and others	104,000	97,900	66,000	60,000
Dutch East Indies	400,000	400,000	1,286,000	1,300,000
Total Asia	9,710,900	9,364,800	8,362,600	8,040,000
Transvaal	938,100	877,500	891,300	800,000
Rhodesia	212,000	175,700	180,500	150,000
Congo and other Africa	32,400	32,500	200,000	200,000
Total Africa	1,182,500	1,085,700	1,271,800	1,150,000
Spain and other Europe	6,511,900	6,871,700	4,900,000	5,000,000
Australasia	10,000,000	10,000,000	7,430,800	3,500,000
Total output in ounces	174,187,800	197,394,900	174,517,900	171,200,000
Total value in dollars	139,835,900	191,022,900	193,924,000	172,700,000
Average price in cents	81.427	96.772	111.122	100.900

Figures for foreign countries are based largely on the statistics collected by the United States Mint where no direct official figures can be obtained.

[1] Estimated.

AVERAGE PRICE OF SILVER IN NEW YORK
(In cents per fine ounce)

Year.		Year.		Year.		Year.		Year.	
1865	$1.337	1875	$1.24	1885	$1.07	1895	$0.65	1905	$0.604
1866	1.339	1876	1.16	1886	0.99	1896	0.68	1906	0.668
1867	1.330	1877	1.20	1887	0.98	1897	0.60	1907	0.653
1868	1.326	1878	1.15	1888	0.94	1898	0.59	1908	0.529
1869	1.325	1879	1.12	1889	0.94	1899	0.60	1909	0.515
1870	1.328	1880	1.15	1890	1.05	1900	0.62	1910	0.535
1871	1.325	1881	1.13	1891	0.99	1901	0.60	.....	.....
1872	1.322	1882	1.14	1892	0.87	1902	0.53	.....	.....
1873	1.297	1883	1.11	1893	0.78	1903	0.54	.....	.....
1874	1.278	1884	1.11	1894	0.63	1904	0.58	.....	.....

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1911	53.795	52.222	52.745	53.325	53.308	53.043	52.630	52.171	52.440	53.340	55.719	54.905	53.304
1912	56.260	59.043	58.375	59.207	60.880	61.290	60.654	61.606	63.078	63.471	72.792	63.365	60.835
1913	62.938	61.646	57.870	59.490	60.361	58.990	58.721	59.293	60.640	60.793	58.995	57.760	57.791
1914	57.572	57.502	58.067	58.519	58.175	56.471	54.678	54.344	53.290	50.654	49.082	49.375	54.811
1915	48.855	48.477	50.241	50.250	49.915	49.034	47.519	47.163	48.680	49.385	51.714	54.971	49.684
1916	56.775	56.755	57.935	64.415	74.269	65.024	62.940	66.083	68.515	67.855	71.604	75.765	65.661
1917	75.630	77.585	73.861	73.875	74.745	76.971	79.010	85.407	100.740	87.332	85.891	85.960	81.417
1918	88.702	85.716	88.082	95.346	99.505	99.500	99.625	100.292	101.125	101.125	101.125	101.125	96.772
1919	101.125	101.125	101.125	101.125	107.135	110.430	106.394	111.370	114.540	119.192	127.924	131.976	111.122
1920	132.827	131.295	125.551	119.779	102.585	90.957	91.971	96.168	93.675	83.480	77.734	64.774	100.900

AVERAGE PRICE OF BAR SILVER IN LONDON
(In pence per standard ounce, 925 fine)

Year.	Pence.	Year.	Pence.	Year.	Pence.	Year.	Pence.	Year.	Pence.	Year.	Pence.	Year.	Pence.
1840.	60.3750	1850	60.0625	1860	61.6875	1870	60.5625	1880	52.2500	1890	47.6875	1900	28.2500
1841.	60.0625	1851	61.0000	1861	60.8125	1871	60.5000	1881	51.6875	1891	45.0625	1901	27.1875
1842.	59.4375	1852	60.5000	1862	61.4375	1872	60.3125	1882	51.6250	1892	39.8125	1902	24.0900
1843.	59.1875	1853	61.5000	1863	61.3750	1873	59.2500	1883	50.5625	1893	35.6250	1903	24.7500
1844.	59.5000	1854	61.5000	1864	61.3750	1874	58.3125	1884	50.6250	1894	28.9375	1904	26.3990
1845.	59.2500	1855	61.3125	1865	61.0625	1875	56.8750	1885	48.6250	1895	29.8750	1905	27.8390
1846.	59.3125	1856	61.3125	1866	61.1250	1876	52.7500	1886	45.3750	1896	30.7500	1906	30.8680
1847.	59.6875	1857	61.7500	1867	60.5625	1877	54.8125	1887	44.6250	1897	27.5625	1907	30.1880
1848.	59.5000	1858	61.3125	1868	60.5000	1878	52.5625	1888	42.8750	1898	26.4375	1908	24.4020
1849.	59.7500	1859	62.0625	1869	60.4375	1879	51.2500	1889	42.6875	1899	27.4375	1909	23.7060

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1910....	24.154	23.794	23.690	24.483	24.797	24.651	25.034	24.428	24.567	25.596	25.680	25.160	24.670
1911....	24.865	24.081	24.324	24.595	24.583	24.486	24.286	24.082	24.209	25.594	25.649	25.349	24.592
1912 ...	25.887	27.190	26.875	27.284	28.038	28.215	27.919	28.375	29.088	29.299	29.012	29.320	28.842
1913....	28.993	28.356	26.669	27.415	27.794	27.195	27.074	27.335	27.985	28.083	27.262	26.720	27.573
1914....	26.553	26.573	26.788	26.958	26.704	25.948	25.219	25.979	24.260	23.199	22.703	22.900	25.313
1915....	22.731	22.753	23.708	23.709	23.570	23.267	22.597	22.780	23.591	23.925	25.094	26.373	23.675
1916....	26.960	26.975	27.597	30.662	35.477	31.060	30.000	31.498	32.584	32.361	34.192	36.410	31.315
1917....	36.682	37.742	36.410	36.963	37.940	39.065	40.110	43.418	50.920	44.324	43.584	43.052	40.853
1918....	44.356	42.792	43.260	47.215	48.980	48.875	48.813	49.077	49.500	49.500	48.969	48.492	47.516
1919....	48.438	48.027	48.171	48.886	52.104	53.896	54.133	58.835	61.668	64.049	70.065	76.432	57.079
1920....	79.846	85.005	74.194	68.848	60.010	51.096	53.736	59.875	59.476	54.197	50.952	41.845	61.590

SILVER PRODUCTION OF THE WORLD, 1856–1920

Year.	Kilograms.	Year.	Kilograms.	Year.	Kilograms.	Year.	Kilograms.
1856–1860 .	4,534,950	1888....	3,385,606	1900.....	5,599,216	1912.....	7,804,516
1861–1865 .	5,505,575	1889....	3,901,809	1901.....	5,438,443	1913.....	6,964,361
1866–1870 .	6,695,425	1890....	4,180,532	1902.....	5,121,469	1914.....	4,995,951
1871–1875 .	9,847,125	1891....	4,479,649	1903.....	5,386,044	1915.....	5,767,844
1876–1880	10,271,210	1892....	4,985,855	1904.....	5,669,124	1916.....	5,246,859
1881.....	2,592,639	1893....	5,339,746	1905.....	5,638,183	1917.....	5,417,972
1882.....	2,769,065	1894....	5,205,065	1906.....	5,683,947	1918.....	6,139,810
1883.....	2,746,123	1895....	5,667,691	1907.....	5,704,083	1919.....	5,428,030
1884.....	2,788,727	1896....	5,496,178	1908.....	6,612,304	1920.....	(e)5,324,000
1885.....	2,993,805	1897....	5,663,304	1909.....	7,069,656	.....	.....
1886.....	2,902,471	1898....	5,575,336	1910.....	7,471,663	.....	.....
1887.....	2,990,398	1899....	5,529,024	1911.....	7,906,446	.....	.....

(e) Estimated. 1 kilogram = 32.15 Troy ounces.

fresh legislation will produce much resistance from silver smelters, and compromise of some sort will be the probable outcome. If, for instance, the re-purchasing price under the Act be reduced from a dollar to whatever be the current quotation (or some fraction above), American production still would not add its quota to the pressure upon the market, for world supplies correspondingly would be reduced.

By Feb. 1, 1921, silver had dropped to 34½d. in London and 57¾ cts. in New York. A rapid decline had set in during January, when sterling exchange advanced sharply to $3.85. The cause was cessation of spot purchases by India, and heavy offerings of futures by China. These prices were the lowest for several years.

In their review of the silver market for 1920 Handy & Harman of New York say:

The threatened difficulties of the first two months of the year, when silver prices, with the exception of a few days, remained at a point above the coinage parity of the United States dollar and frequently approached close to that of our subsidiary coins, were, however, soon forgotten, for by the middle of April, the downward trend had started in earnest. From the year's high price in New York of $1.37 on Jan. 12, commercial bar silver of foreign origin finally dropped to 59¼ cts. on Dec. 10—a fall of over 77 cts. despite the deterring effect on the market of our Government's purchases under the Pittman Act. A similarly violent reaction had taken place in the London market, where a low of 38⅞d. was reached on Dec. 10 after a high record of 89½ had been attained on Feb. 11. The year's low quotations in both London and New York are the lowest prices for either market since those of July, 1917, in England, and March,

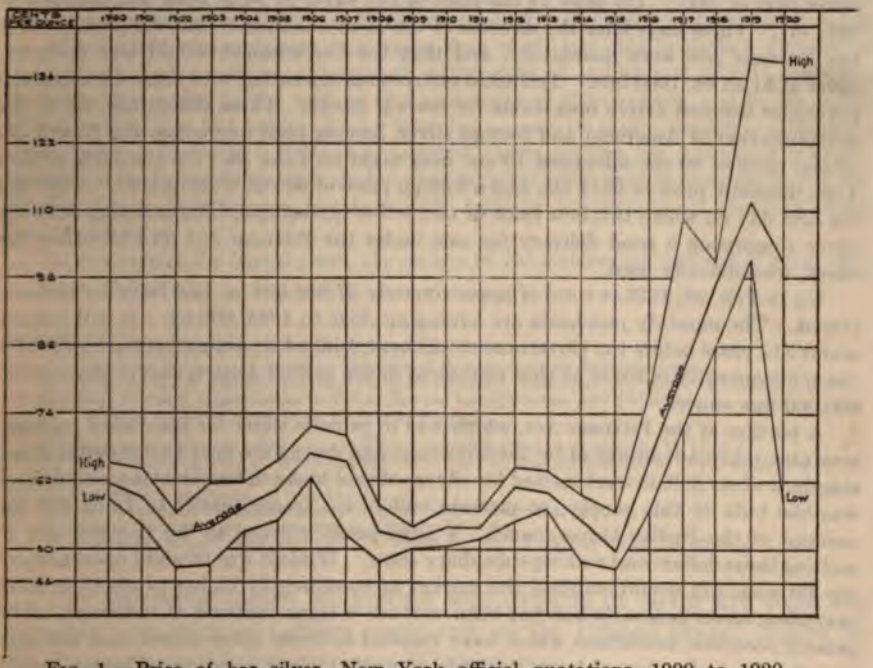


FIG. 1.—Price of bar silver, New York official quotations, 1900 to 1920.

1916, in this country. A study of the price ranges of former years not only shows the market fluctuations to have been more frequent than ever before, but also that the rapid fall of 1920 has been of even greater extent and considerably more abrupt than that of the early nineties. The decline in the London price from about the middle of 1890 to the close of 1894 was from 54½ to 27¼d. and covered a period of 4½ years; whereas that of 1920 occurred in less than 11 months and represents a drop of 50⅝d. This decline marks an epoch in the commercial silver market, one which is not likely to be equaled for many years to come.

The following table, which gives the average official price of commercial bar silver in New York, during 1920, shows the steady downward trend of the market; reactions took place in July and August, but these upward movements proved only temporary.

Month.	Price.
January	$1.32826
February	1.31295
March	1.25551
April	1.19778
May	1.02585
June (foreign silver)	0.90957
July (foreign silver)	0.91971
August (foreign silver)	0.96168
September (foreign silver)	0.93675
October (foreign silver)	0.83480
November (foreign silver)	0.77734
December (foreign silver)	0.64774

Re-purchase of silver under the terms of the Pittman Act of April, 1918, to replace dollars melted and shipped out of this country, to aid our allies in war, was begun the latter part of May. On May 14 the price of bar silver in New York had dropped to 99¾ cts. Three days later the director of the Mint announced that the provisions of the Pittman Act were mandatory, and that the Government would buy domestic silver at $1 an oz. 1000 fine. Technical restrictions connected with these Government purchases delayed active operations for several weeks. These difficulties, as to the differentiation of American and foreign silver, having been overcome, the New York official price of 80 cts. advanced 10 cts. over night on June 16. On the 17th, a New York domestic price of 99½ cts. and a foreign price of 90 cts. were quoted. This was the first day on which this new basis of two sets of quotations, differentiating between silver comprising a good delivery for sale under the Pittman Act and all other bar silver, was officially used.

Up to Feb. 20, 1921, a total of approximately 37,000,000 oz. had been bought and stored. The monthly purchases are averaging close to 4,000,000 oz. It will require about 3½ years before the Government will have fulfilled its obligation to re-purchase the same quantity of silver as that contained in the melted dollars, that is about 208,900,000 fine ounces.

A portion of the Pittman Act, which was to provide silver for subsidiary coinage, was also taken advantage of by the Treasury, and during the year 10,000,000 of these standard silver dollars were melted for silver coins of lower denominations, and not, as was the bulk of this supply, to provide bullion for transhipment to India for the account of the British Government. A large profit accrued to the Government in melting these dollars and making subsidiary coins. While it was thought operations of the Pittman Act would stabilize the market at considerably higher prices than have prevailed, nevertheless, it has not been without a large measure of influence. The general economic conditions which have resulted in lower silver prices, and the continued sales in London of large amounts of melted silver coin from Europe, would without doubt have brought about a more severe reaction if the world's supply of silver had not been reduced by the 30,000,000 oz. already absorbed by our Government. Coinage of silver dollars, the first time since 1905, to replace those melted and sold as bullion, was started at the Philadelphia Mint on Feb. 19, 1921.

While China for the last two or three years has been a large purchaser of silver to replace the amount, estimated at 77,000,000 oz., sold to India in the years 1914 to 1917, it has apparently reached the point of saturation for the present. Owing to the difficulty of obtaining reliable statistical information from that country, the data at hand are not sufficient to explain, or even for the student to theorize, on China's exchange formulas in a popular way. Expert and technical knowledge are required. But in regard to India, light on the subject is more available. The Commission appointed in 1919 by Great Britain to inquire into the Indian exchange and currency reforms has furnished much valuable information, and the report being an official

document has the merit of reliability. Various recommendations in regard to the functions of the rupee were offered and adopted by the Secretary of State to stabilize this unit of value, but it is a difficult if not impossible task to accomplish.

Some extracts from the report are interesting. India has a population of 315 millions. It contains 2250 towns with 30 million, and over 700,000 villages with 285 million inhabitants. In the whole country there are less than 200 towns with banking facilities. As a writer has well said: "Their money lies dormant in endless small hoards, and the financial power of India is poorly mobilized." Collections of the scattered resources of the country are either buried in the ground, or worn as ornaments, and are therefore useless for stimulating trade activities. It is estimated between 3 and 4 billions of rupees are held in India,—either in circulation, or melted down into bullion, or hoarded in secret places, according to customs handed down from generation to generation. If these sums of metallic value were conserved in banking depositories and trust companies, they would not only bring in a revenue to the owners, but could be invested in enterprises of public and private character that would redound to the welfare and prosperity of the country, and to the uplift of individual life; but habits of long standing cannot be easily changed. Usually a large balance of trade is created in favor of India, making her a creditor country. Exports in the period 1914–1919 totaled £744,000,000, while imports were £492,000,000. Settlement of this balance has invariably been by importation of gold and silver, mostly the latter.

To summarize the past 6 years, the causes of the sudden rise and fall of silver may be given as follows:

As to the rise—
(1) Heavy demand for Indian currency since 1914.
(2) Enormous bullion purchases by the British Government on India account.
(3) Large excess of merchandise exports from Bombay, Calcutta, and other Far Eastern ports.
(4) Huge military expenditures in India, Egypt, Mesopotamia, and Palestine.
(5) Embargo on silver imports on private account.

As to the fall—
(1) Cessation of bullion purchases on United States Government account in 1919.
(2) Unfavorable balance of trade against India for the last six months of 1920, as shown by the large amount of Reverse Council Bills sold.
(3) Unfavorable monsoon, or lack of rain.
(4) The substitution of paper money in place of the silver rupee.
(5) Serious famine in five important provinces of China.
(6) Dullness of export trade during 1920, owing to limited resources and low prices.

The following tables of imports and exports of silver are from the monthly summary of foreign commerce of the United States, issued by the Department of Commerce at Washington.

SILVER MOVEMENTS

Imports.		Exports.	
Year.	Value.	Year.	Value.
1911	$43,746,571	1911	$65,665,646
1912	48,401,086	1912	71,961,755
1913	35,867,819	1913	62,776,631
1914	25,959,187	1914	51,603,060
1915	34,483,954	1915	53,598,884
1916	32,263,289	1916	70,595,037
1917	53,340,477	1917	84,130,876
1918	71,375,699	1918	252,846,464
1919	89,410,018	1919	239,021,051
1920	88,060,041	1920	113,616,214

Country.	Imports from			Exports to		
	1918.	1919.	1920.	1918.	1919.	1920.
France	$193,945	$75,524	$117,508	$5,059,922	$6,588,197	$39,920
United Kingdom	142,104	61,746	925,520	32,687,841	15,635,386	4,924,778
Canada	7,641,496	7,121,469	3,788,435	3,606,561	7,854,378	7,061,755
Central America	3,033,759	5,200,481	7,198,851	.....	.....	4,009,710
Mexico	51,017,055	63,303,437	53,197,337	2,792,086	1,926,433	3,241,090
West Indies	278,492	90,467	209,444	91,765	162,789	1,656,507
Brazil	3,987	2,155	.....	.....	.....	2,333
Chile	2,160,575	1,927,324	3,744,351	.....	.....	.....
Colombia	210,327	271,274	846,404	.....	2,000	.....
Peru	5,115,577	8,862,537	11,990,677	.....	.....	.....
Venezuela	1,019	2,521	905	.....	850,000	10,000
China	.....	.....	.....	23,786,077	77,583,367	61,347,610
East Indies	248,223	1,773,584	2,671,555	.....	.....	.....
Argentina	.....	.....	37,324	178,621	3,867	13,173
India	.....	.....	.....	163,154,135	109,180,718	642,408
Hongkong	.....	20,000	.....	19,322,299	10,245,351	24,872,571
Other countries	1,329,140	647,499	3,331,730	2,167,157	8,988,337	8,801,369
	$71,375,699	$89,410,018	$88,060,041	$252,846,464	$239,021,051	$113,616,224

In discussing editorially the position of silver, the *Mining and Scientific Press*[1] had the following to say:

Revival of mining in Mexico has been checked temporarily by the drop in the price of foreign silver, despite the stabilizing effect of purchases of American silver under the Pittman Act. The metal is produced most cheaply in the Pachuca district, where the cost is slightly under 60 cts. per oz.; in other parts of Mexico the cost of production at the smaller mines is about 80 cts., the general average being about 70 cts. per oz. In the United States the cost ranges between 40 and 80 cts., excluding the by-product silver incidental to exploitation of ores valuable chiefly for the base metals, copper, lead, and zinc. At Cobalt, in Canada, the average cost is about 50 cts., with a low figure of 37 cts. for the Nipissing mine. It is obvious that if the market price remains near 60 cts., it will be necessary for many, if not most, of the silver mines outside the United States to cease operations. That, of course, will tend at once to correct the sag in price by increasing the demand, which has fallen off for two principal reasons, of which the chief is the temporary cessation of buying from China. During the war the prosperity of the Chinese caused them to buy silver freely, such buying being further stimulated by the fact that Great Britain and others among the Allies stripped China bare of silver in order to adjust their balances in the Far East. The employment of Indian troops in Mesopotamia and Egypt, and of Chinese in France, called for a large supply of silver coinage. These various abnormal conditions opened a voracious market for silver in the Orient. In Europe likewise the payment of soldiers made a call on silver coins of every kind. Since the war the depreciation of paper money has been so great that it has been profitable to melt silver and exchange it at a large premium for paper currency. A final blow at the weakening market was delivered by the French Government when recently it decided to sell 40,000,000 oz. of silver at the rate of 400,000 oz. per week, in order to meet pressing financial demands. General conditions, as will be seen, have been extremely unfavorable to the maintenance of what the miner would consider a fair price for his product. The purchases under the Pittman Act have checked the collapse somewhat. Meanwhile the silver being produced in Mexico is being coined rapidly, thereby helping to cure the inflation

[1] **122**, 37 (1921).

of the currency caused by "infalsifiable" paper of various kinds and denominations. The coinage of Mexican silver is proceeding at the rate of 24,000,000 oz. per annum, equivalent to about a third of the normal production. This will be a factor in restoring economic conditions in that country. Our miners are still the beneficiaries of the Pittman Act. Conditions are bad, but they might be much worse. Before they do become worse, it is likely that the decrease of production, in Canada and elsewhere, partly incidental to the curtailment of copper mining, will tend to correct the present unfavorable status of silver.

The present price situation in silver is a subject of serious concern to the domestic silver producer, even though he is temporarily in a protected position through the operation of the Pittman Act.[1]

Just what the policy of the domestic producer should be under present conditions could be determined with more or less accuracy were the trend of the world silver market known. Are present prices going to continue for several years or not? Is the present low price due to sympathetic reaction downward following the sagging in prices of copper, lead, and zinc? Undoubtedly to some extent, we would say with reference to the second question; but the first question is dependent upon conditions so far in the future as to defy anything more than speculation.

For the immediate future, C. W. Handy, at the last meeting of the New York section of the American Institute of Mining and Metallurgical Engineers, said that there was not any great strength to the silver market. Without much doubt silver prices will move in accordance with supply and demand. Before the war period and for a number of years silver prices were low. It should therefore be reasonable to expect that with an approximate return to normal economic conditions silver would be in much the same position as prevailed before the war. There would, however, be this difference: the several years of curtailed copper production will result in a definite decrease in the supply of silver produced from the treatment of certain copper ores. There will also be less silver produced from the reduction in the quantity of silver-lead ores. New producers of silver are not numerous. Mexico at present is curtailing the operation of silver mines, owing to the existing low price of the metal. It would therefore appear certain that the supply of silver in 1920 and 1921 would be less than formerly. Future prices, other things being equal, should be higher than those prevailing before the war. We are inclined to be cheerful about the resumption of the world's industry after the prevailing deflation has run its course. We feel that industry will be accelerated and commodity prices will advance from the ebb prices which are undoubtedly upon us at this time and for probably some time in the future.

Viewing the position of the domestic silver producer more in detail, it appears to us that somewhat lower supply costs and increased efficiency of operations are in course and will become more pronounced as time goes on. The per-ounce cost of silver production should show a steady decline with a constancy in grade of ore and size of orebody. Looked at in another way, a greater tonnage of low-grade ore should become available for mining. It is a well-recognized principle in mining that the rate of production should be kept at a maximum in order to reduce unit costs to a minimum. Needless to say, a minimum unit cost would mean a maximum return on the basis of the fixed price now existing. It would therefore appear to us that domestic silver producers other than those who are producing silver as a by-product of some other metal should attain a production rate that would insure this minimum cost of produc-

[1] *Eng. Min. Jour.* **110** 1203 (1920).

tion as speedily as possible. There should also be persistent effort to secure the maximum operating and administrative efficiency.

It has been remarkable and instructive to students of economics to see how the fixing of price by the Pittman Act failed to stabilize the world price of silver, or even arrest its collapse. It might be added that when the Government has completed its purchases (about 40,000,000 oz. have been bought to March, 1921) of some 208,000,000 oz. required under the Act, American producers will have to face the sharp drop to foreign prices, as the market will then be an open one, without Government support. An international association of silver producers was suggested by Blamey Stevens.[1] He considered that the severe fluctuation in the the price of silver, in the open market, during the last year, is the very strongest argument to the governments of the world that silver is no longer a suitable metal to be used as money. Some of these governments will not look favorably upon the loss in value of their reserves, due to an abnormal drop in the price of silver. Others will lose confidence if they have to be repeatedly switching currency laws to follow an unstable market. Those individuals accustomed to hoard it will also lose confidence in its pre-eminence as an article of permanent value. In fewer words, a fluctuating price for silver means a continued reduction of demand and consequently a serious and permanent factor in the reduction of average silver prices. In fine, Mr. Stevens thinks that the burden of proper regulation of market prices rest between the governments and the producers.

H. W. Miller[2] discussed this suggestion, also that of Mr. Butters, mentioned elsewhere. He was surprised at Mr. Stevens' idea, and thought that the remedy lay in an international conference adopting a definite ratio between gold and silver with a definite proportion of credit expansion that would govern all nations alike, so that the different nations would ultimately adjust their coinage to that ratio, and the gold and silver money would become eventually international currency. According to Mr. Miller, the Butters plan had received the "cold shoulder."

A short history of silver in monetary systems, the rise of London in the control of the market, the increased interest manifested by Americans, the importance of the world's stocks of silver as a factor in the situation, and the desirability of an open market were the main points in an address by C. W. Wheelock before the New York Section of the American Institute of Mining & Metallurgical Engineers on Dec. 8, 1920. The principal point was that London controls the market because it has every

[1] *Min. Sci. Press*, **121**, 864 (1920).
[2] *Min. Sci. Press*, **122**, 39 (1921).

facility for the sale and distribution of the metal throughout the world, especially in China and India.

A plea for the greater use of silver, and the payment of current obligations to tradespeople and the distribution of dividends by silver-mining companies in units of their metallic products, was made by Charles Butters in the *Mining and Scientific Press*.[1] The Editor of that journal was somewhat skeptical,[2] but F. L. Sizer thought it a good idea,[3] of even greater benefit than the proposed bonus on gold.

The fall in the price of silver affected Mexican mining considerably, and many properties were closed. To aid matters, the Mexican Government removed the export duty on silver. When the value of silver on the New York market, as determined by the Secretary of Hacienda, either in ten-day or monthly periods, is less than 60 cts. per oz., no duty will be levied.

Value of Silver.	Duty to be Levied, Per Cent. Ad Valorem.
$0.60 to $0.70	1
0.70 to 0.80	1½
0.80 to 0.90	2
0.90 to 1.00	7
1.00 to 1.10	8
1.10 to 1.20	9
1.20 to 1.30	10
1.30 to 1.40	11
Over $1.40	12

The decree of June 15, 1920, is abrogated under the terms of the new decree. The purpose, as stated, is "to co-operate for the solution of the present prices in the mining business and to protect the mining companies sufficiently to enable them to make profit and at the same time contribute to the Government in proportion to their earnings."

Canadian silver producers were also affected considerably, and a suggestion was made by F. A. Starkey of Nelson, B. C., that the Dominion Government fix the price at 80 cts. per oz., and mint more dollars. The period would be up to two years. As silver dollars were minted, it was proposed to withdraw dollar bills from circulation.

In a front-page item entitled "Coining Dollars at a High Price" and in an editorial under the caption "The Silver Crime of 1921," the *New York Times* of Feb. 21 and Feb. 25, 1921, attacked the Pittman Act and the Government's purchasing silver at $1 when the open market was under 60 cts. The tone was quite uncalled for, and was challenged in the issue of Mar. 1 by S. R. Wagel, an authority on silver, who showed that the *Times* was entirely incorrect.

Under the caption of "The Financial Situation" the Pittman Act was further attacked.[4] This country is considered to be "groaning under the burden of an unbearable load of taxation. . . and under the

[1] **121,** 5, 185 (1920).
[2] **121,** 2 (1920).
[3] **121,** 298 (1920).
[4] *Com. Fin. Chronicle,* 112, 682 (1921).

so-called Pittman Act it (the Government) is purchasing a large block of silver each week at a price nearly double the market value . . . in other words, the silver producers are getting a bonus of 41 cts. for every ounce they are producing and turning over to the government . . . 174,000,000 oz. more to be bought . . . if the whole of this should be purchased at $1 an oz., while the market price is only 58 cts. an oz., the loss to the government and the clear bonus to the silver producers would reach the prodigious sum of $70,000,000 . . . a monstrous wrong to the country . . . instant repeal of this iniquitous law . . .." This argument is in line with that in the *New York Times*, mentioned above, neither of which has thoroughly studied the silver status.

Gold and Silver Mining in the United States

The preceding pages show the condition of the industry in this country, and the following notes tell what happened during 1920 and what may be expected in 1921 in the various districts. Acknowledgment for preliminary production figures and for a good deal of the text should be made to the U. S. Geological Survey.

The following tables show the United States production of precious metals from 1883 to 1920:

GOLD

Year.	Ounces.	Value.	Year.	Ounces.	Value.	Year.	Ounces.	Value.
1883	1,451,250	$30,000,000	1896	2,568,132	$53,088,000	1909	4,821,701	99,673,400
1884	1,489,950	30,800,000	1897	2,774,935	57,363,000	1910	4,657,018	96,269,100
1885	1,538,373	31,801,000	1898	3,118,398	64,463,000	1911	4,687,053	96,890,000
1886	1,686,788	34,869,000	1899	3,437,210	71,053,400	1912	4,520,717	93,451,500
1887	1,603,049	33,136,000	1900	3,829,897	79,191,000	1913	4,299,783	88,884,400
1888	1,604,478	33,167,500	1901	3,805,500	78,666,700	1914	4,572,976	94,531,800
1889	1,594,775	32,967,000	1902	3,870,000	80,000,000	1915	4,887,602	101,035,700
1890	1,588,877	32,845,000	1903	3,560,000	73,591,700	1916	4,479,051	92,590,300
1891	1,604,840	33,175,000	1904	3,892,480	80,464,700	1917	4,051,440	83,750,700
1892	1,597,098	33,015,000	1905	4,265,742	88,180,700	1918	3,320,784	68,646,700
1893	1,739,323	35,955,000	1906	4,565,333	94,373,800	1919	2,918,622	60,333,400
1894	1,910,813	39,500,000	1907	4,374,827	90,435,700	1920	2,395,017	49,509,400[1]
1895	2,254,760	46,610,000	1908	4,574,340	94,560,000			

[1] Preliminary estimate.

SILVER

Year.	Ounces.	Commercial Value.	Year.	Ounces.	Commercial Value.	Year.	Ounces.	Commercial Value.
1883	35,732,800	$39,618,400	1896	58,834,800	$39,654,600	1909	54,721,500	28,455,200
1884	37,743,800	41,921,300	1897	53,860,000	32,316,000	1910	57,137,900	30,854,500
1885	39,909,400	42,503,500	1898	54,438,000	32,118,400	1911	60,399,400	32,615,700
1886	39,694,000	39,482,400	1899	54,764,500	32,858,700	1912	63,766,800	39,197,500
1887	41,721,600	40,887,200	1900	57,647,000	35,741,100	1913	66,801,500	40,348,100
1888	45,792,700	43,045,100	1901	55,214,000	33,128,400	1914	72,455,100	40,067,700
1889	50,094,500	46,838,400	1902	55,500,000	29,415,000	1915	74,961,075	37,397,300
1890	54,516,300	57,242,100	1903	54,300,000	29,322,000	1916	74,414,800	48,953,000
1891	58,330,000	57,630,000	1904	57,682,800	33,456,000	1917	71,740,400	59,078,100
1892	63,500,000	55,662,500	1905	56,101,600	34,222,000	1918	67,810,139	66,485,129
1893	60,000,000	46,800,000	1906	56,517,900	38,256,400	1919	56,682,445	63,533,652
1894	49,500,000	31,422,100	1907	56,514,700	37,299,700	1920	56,564,504	57,420,325[1]
1895	55,727,000	36,445,500	1908	52,440,800	28,050,600			

[1] Preliminary estimate.

PRODUCTION OF GOLD IN THE UNITED STATES, BY STATES (a)

States.	1917.		1918.		1919.		1920.	
	Fine Ounces.	Value. (b)	Fine Ounces.	Value. (b)	Fine Ounces.	Value. (b)	Fine Ounces.	Value. (b)
Alabama	106	$2,200	36	$700	.....	.....	10	$200
Alaska	709,729	14,671,400	440,622	9,108,500	481,984	$9,963,500	380,034	7,856,000
Arizona	250,613	5,180,600	278,647	5,760,200	222,965	4,609,100	239,118	4,943,000
California	1,012,461	20,929,400	842,389	17,207,000	841,638	17,398,200	692,019	14,305,300
Colorado	772,766	15,974,500	621,791	12,853,500	495,810	10,249,300	368,298	7,613,400
Georgia	314	6,500	169	3,500	34	700	53	1,100
Idaho	36,511	754,800	30,764	636,000	34,085	704,600	22,509	465,300
Maine	.....	.....	.....	.....	10	200	.....	.....
Missouri	15	300	10	200	14	300	19	400
Montana	177,690	3,673,200	153,375	3,170,600	116,918	2,416,900	88,971	1,839,200
Nevada	335,361	6,932,500	322,276	6,662,000	225,384	4,659,100	171,968	3,554,900
New Mexico	52,505	1,085,400	30,871	638,200	28,319	585,400	22,417	463,400
North Carolina	524	10,800	38	800	5	100	53	1,100
Oregon	81,624	1,687,300	60,951	1,260,000	53,029	1,096,200	46,687	965,100
South Carolina	82	1,700	.....	.....	5	100	14	300
South Dakota	356,662	7,372,900	328,305	6,786,700	255,889	5,289,700	203,243	4,201,400
Tennessee	267	5,500	263	5,400	271	5,600	280	5,800
Texas	5	100	5	100	19	400	5	100
Utah	170,353	3,522,100	152,018	3,142,500	109,661	2,266,900	100,446	2,076,400
Vermont	5	100	47	800	19	400	.....	.....
Virginia	63	1,300	20	400	.....	.....	.....	.....
Washington	23,617	488,200	16,556	342,300	11,436	236,400	7,198	148,800
Wyoming	179	3,700	18	400	14	300	10	200
Total	3,981,482	$82,304,500	3,269,171	$67,579,800	2,877,509	$59,483,400	2,343,352	$48,441,400
Porto Rico	5	100	.....	.....	.....	.....	97	2,000
Philippine Islands	69,953	1,446,100	44,202	913,700	41,119	850,000	51,568	1,066,000
Total	4,051,440	$83,750,700	3,313,373	$68,493,500	2,918,628	$60,333,400	2,395,017	$ 49,509,400

(a) The statistics in this table are reported by the Director of the Mint, those for 1920 being the preliminary figures. (b) At $20.67 per oz.

SILVER PRODUCTION OF THE UNITED STATES, BY STATES (a)

	1918.		1919.		1920.	
	Fine Ounces.	Value. (b)	Fine Ounces.	Value. (c)	Fine Ounces.	Value. (d)
Alaska	796,836	$796,836	690,151	$773,790	792,751	$804,745
Arizona	6,771,490	6,771,490	5,702,911	6,392,222	6,098,251	6,190,518
California	1,555,417	1,555,417	1,153,614	1,293,051	1,513,495	1,536,394
Colorado	6,982,313	6,982,313	5,966,606	6,687,790	5,572,407	5,656,718
Georgia	43	43	8	9	140	142
Idaho	10,188,056	10,188,056	5,933,076	6,650,207	7,531,253	7,645,201
Illinois	8,939	8,939	6,000	6,725	8,500	8,629
Maine	.....	.....	4,142	4,643	.....	.....
Maryland	164	164	.....	.....	.....	.....
Michigan	491,939	491,939	425,610	477,054	510,601	518,326
Missouri	40,948	40,948	75,991	85,176	123,219	125,083
Montana	15,341,793	15,341,793	15,012,258	16,826,790	13,583,164	13,788,677
Nevada	10,113,405	10,113,405	7,095,395	7,896,972	7,392,689	7,504,540
New Hampshire	.....	.....	.....	.....	.....	.....
New Mexico	763,758	763,758	851,821	954,781	764,586	776,154
North Carolina	9	9	19	21	11	11
Oklahoma	.....	.....	.....	.....	.....	.....
Oregon	150,207	150,207	236,620	265,220	182,558	185,320
Philippine Islands	12,537	12,597	15,715	17,614	21,917	22,249
Porto Rico	.....	.....	.....	.....	135	137
South Carolina	.....	.....	2	2	.....	.....
South Dakota	165,865	165,865	122,068	136,822	84,351	85,627
Tennessee	131,931	131,931	97,554	109,345	112,595	114,299
Texas	612,436	612,436	539,483	604,690	524,212	532,143
Utah	13,439,811	13,439,811	12,542,623	14,058,650	11,564,155	11,739,121
Vermont	5,117	5,117	2,200	2,466	.....	.....
Virginia	2,967	2,967	8	9	.....	.....
Washington	302,406	302,406	258,270	289,487	183,437	186,213
Wyoming	719	719	300	336	72	73
Total	67,879,206	$67,879,206	56,682,445	$63,533,652	56,564,500	$57,420,325

(a) Figures of the Bureau of the Mint and the U. S. Geological Survey, those for 1920 being a preliminary estimate. (b) At $1 per oz. (c) At $1.121 per oz. (d) At $1.015 per oz.

Alaska.—The mining industry suffered a serious depression during 1920, and the gold output fell once more. The returns from lode mining were fairly well maintained—3,270,000 tons of ore yielding $4,360,000 of gold against 3,262,573 tons and $4,392,237 in 1919—but placer mines yielded only $3,630,000, compared with $4,970,000 in 1919.

Production during the past 16 years is as follows:

Year.	Gold.		Silver.	
	Ounces.	Value.	Ounces.	Value.
1905	756,101	$15,630,000	132,174	$80,165
1906	1,066,030	22,036,794	203,500	136,345
1907	936,043	19,349,743	149,784	98,857
1908	933,290	19,292,818	135,672	71,906
1909	987,417	20,411,716	147,950	76,934
1910	780,131	16,126,749	157,850	85,239
1911	815,276	16,853,256	460,231	243,923
1912	829,435	17,145,951	515,186	316,839
1913	755,947	15,626,813	362,563	218,988
1914	762,596	15,764,259	394,805	218,327
1915	807,966	16,702,144	1,071,782	543,393
1916	780,037	16,124,800	1,266,317	833,000
1917	733,911	15,171,300	1,351,100	1,099,800
1918	455,920	9,424,700	802,743	787,057
1919	481,984	9,963,500	690,151	773,790
1920[1]	380,034	7,856,000	792,751	804,745

[1]Preliminary estimate.

The total for 41 years is $320,000,000, of which $221,642,000 was from placers.

One of the most encouraging features of the year's mining, according to the U. S. Geological Survey, was the systematic development of a large auriferous lode in the Nixon Fork (McGrath) district in the upper Kuskokwim valley. The 31 claims are under option to the Alaska Treadwell interests for 4 or 5 years. By mid-year a 100-ft. shaft had disclosed several lenses of ore assaying over $30 per ton in gold, silver, and copper. This orebody gives promise of being valuable, and if it so proves it will assure the beginning of a lode-mining industry in this remote region. Auriferous mineralization appears to be rather widely distributed in the Kuskokwim basin, a region which has been relatively little prospected. The gold occurs in association with granitic rocks, which are intruded into limestone and other little-altered sedimentary rocks. In general the strong mineralization appears to be more localized than that in the schist areas of the upper Yukon. Such conditions are favorable to the occurrence of commercial orebodies. The discovery of this lode and the continued success of the Candle Creek dredge, near McGrath, has attracted attention to the Kuskokwim basin, and there has consequently been more prospecting in this province than in any other part of inland Alaska. Especially noteworthy has been the considerable

search and tests for dredging ground in the Kuskokwim and immediately adjacent region during the last two years.

Though lode mining in southeastern Alaska is still chiefly confined to the low-grade ores of Juneau, the development of which is most seriously handicapped by existing conditions, yet there was in 1920 a marked increase in the prospecting for auriferous lodes in this field, notably in the Sitka district. Some promising discoveries of auriferous quartz were made on Chichagof island.

Important also are the activities in the Willow Creek district, tributary to the Government railroad, directed to the consolidation of some auriferous lode properties and their development on a large scale.

Concerning the great lode mines near Juneau, the position might be summarized by saying that the Alaska Treadwell group reports nothing of note, save that it is interested in some promising gold-silver-copper claims on a branch of the Kuskokwim River, in southwestern Alaska; the Alaska Juneau, by means of remodeling its system of treatment and discarding about 60 per cent. of the ore as waste, is now making good profits, about 14 cts. out of $1.15 ore; and the Alaska Gastineau continues to mill about 2,200,000 tons of 86-ct. ore per annum, at a loss of 14 cts. per ton. The last-mentioned company's power plants and part of the mill will probably be sold to a pulp and paper company.

Gold dredging has declined relatively less than other forms of placer mining, partly because some of the dredges are working rich ground and partly because the investments in this form of industry are so large that many companies continue operations even with small profits. In 1919 there were 28 dredges operated in Alaska, which produced gold worth $1,360,000; in 1920 there were 22 dredges operated, yielding $1,020,000. The relative efficiency of gold dredging compared with other methods of placer mining is illustrated by the fact that in 1920 about 300 men, or 16 per cent. of the total placer miners employed in Alaska, produced $1,020,000, or 28 per cent. of the total placer gold recovered.

In 1920 there were 17 gold dredges operated in the Seward Peninsula, 2 in the Iditarod and Fairbanks districts, and 1 in the Mt. McKinley (McGrath) district. Improvements are being made in the Cache Creek dredge, in the Yentna district, and this will probably be operated next year. Plans are also being made for erecting two dredges in the Innoko district, and for the exploitation of other dredging ground in the Kuskokwim region. Owing to present high operating costs, most dredging companies will consider only placers whose gold content is 75 cts. or more per cu. yd. The average recovery of the dredges in Seward Peninsula in 1919 was only 52 cts., and the extensive reserves of dredging ground in the peninsula are consequently now attracting little attention.

As so little is heard of mining in the Ketchikan district, the paper[1] by Joseph Ulmer will be found of interest. The first location was in 1867. While most of the mines are copper producers, we find that the Goldstream claims yielded $200,000 in gold up to several years ago; and the Kasaan Gold Co. has 100,000 tons of ore developed, and operates a 100-ton flotation mill.

Among the official recommendations for the betterment of the Territory are an increased appropriation for geologic investigations, and an appropriation of $1,000,000 by Congress to start a 10-year program of road construction.

Most of the first 260 miles of the Government Railroad starting at Anchorage is complete; also the last 100 miles to Fairbanks, leaving 108 miles to be constructed.

Now that the railroad to the interior is nearing completion, renewed attention is being given to the question of power. The Alaska Station of the U. S. Bureau of Mines, in charge of John A. Davis, has been making an investigation into this, and has published the results.[2] The future of the Fairbanks district, where there are estimated to be hundreds of millions of yards of gravel and workable lodes, depends upon coal from the Nenana field. This is from 100 to 125 miles from the Fairbanks properties, the railroad connecting them. Coal (lignite) reserves are over 9,000,000,000 tons. Climatic conditions preclude the use of water-power in the region. As it would not pay to build spur lines to the various properties for conveyance of coal, it is proposed to erect a central power-station in the coal field, and transmit electricity to Fairbanks, also to the Tolovana, Hot Springs, Bonnifield, and Kantishna districts. The initial unit at Nenana would be of 5000 hp., costing $4,750,000. Eventually it could be quadrupled at about double that cost. Power would be sold at $100 per annum, just 12 per cent. of the present cost of generating power at Fairbanks. The future of the interior depends upon mining, the mining on cheap power, and agricultural development on both.

Many Alaskans were surprised to read that frozen gravel can be thawed more readily with cold water than with steam, but W. S. Weeks has described[3] the results obtained at Nome by J. H. Miles of Trinity Center, Calif. Until recently it was considered that steam points were necessary for disintegrating such gravel. The method was developed after 1898. It loosens much gravel, but is wasteful. It is now found that cold water (52° F.) will thaw 511 cu. yd. of gravel against 109 cu. yd. by steam. Whereas clay is an impediment in steam thawing, it is no hindrance to cold water. A vigorous circulation of water must be kept up, and just enough water should be used to keep the temperature of the

[1] *Pathfinder*, Aug., 1920.
[2] *Min. Sci. Press*, **120**, 367 (1920).
[3] Proc. Am. Min. Congress, **23** and **24**, 1919 and 1920.

outgoing water, say 20 gal. per min., a little above freezing. The cost is 2 cts. per yd., much lower than when thawing by steam.

Arizona.—Production during the past seven years is as follows.

Year.	Gold.		Silver.	
	Ounces.	Value.	Ounces.	Value.
1914	221,020	$4,568,900	4,439,500	$2,455,000
1915	220,392	4,555,900	5,665,672	2,826,500
1916	197,989	4,092,800	6,680,252	4,394,600
1917	267,700	5,533,800	6,962,257	5,754,700
1918	270,078	5,583,000	6,831,465	6,831,465
1919	222,965	4,609,100	5,702,911	6,392,222
1920[1]	239,110	4,943,000	6,098,250	6,190,510

[1] Preliminary estimate.

The gold produced by mines in Arizona increased from $4,506,413 in 1919 to about $4,686,000 in 1920 according to V. C. Heikes. This increase was a result of the slight improvement in the production of gold from copper ore and the steady output from the Oatman region. More than half the output of gold from Arizona came from gold ores in the San Francisco district, in Mohave County. The United Eastern company remained the largest producer of gold in the State. Its output was $2,239,711 from 102,926 tons of ore. The profit was $2,226,700, of which $981,370 was paid in dividends. The yield was $400,000 more than in 1919. Ore reserves are valued at $6,000,000 gross. Costs in 1920 were $8.75 per oz. of gold. The Tom Reed Co. continued its large output, about $900,000, and paid $201,000 in dividends. This company started an apex suit against the United Eastern, but the decision on this complex dispute was rendered against it. Of the copper properties, the Calumet & Arizona, United Verde, and Copper Queen mines were the largest producers of gold.

The mine output of silver increased from 5,266,605 oz. in 1919 to 5,532,000 oz. in 1920, and the value increased from $5,898,598 to $6,032,000. The largest producers of silver were the copper mines of the Calumet & Arizona, Copper Queen, United Verde, Magma, and United Verde Extension mines. Besides these mines, the largest producers of silver were the Shattuck mine, the Bunker Hill mine at Tombstone, and the Commonwealth, at Pearce.

California.—General conditions were decidedly adverse to gold mining during 1920, according to Charles G. Yale. One of the causes affecting production was the shortage of hydro-electric power in the fall; both deep mines and dredges suffered alike in this respect. Labor is unsatisfactory. Prospecting has almost come to a standstill.

The past 15 years' records show the following output:

Year.	Gold, Value.	Silver, Oz.
1906	$18,732,452	1,220,641
1907	16,727,928	1,138,858
1908	18,761,559	1,647,278
1909	20,237,870	2,098,253
1910	19,715,440	1,840,085
1911	19,738,908	1,270,445
1912	19,713,478	1,300,136
1913	20,406,958	1,378,399
1914	20,653,496	1,471,859
1915	22,442,296	1,678,756
1916	21,980,400	1,936,910
1917	20,087,504	1,989,800
1918	16,784,400	1,432,812
1919	17,398,200	1,153,614
1920	14,311,043	1,706,327

Without the dredging industry, gold mining would be at a low ebb. Last year 49 per cent. of the total was recovered by dredging. About 45 boats are now at work. Yuba County leads all other counties in output, due to the Yuba Consolidated, which recovered $3,213,213 from 23,523,000 cu. yd. during the period ended Feb. 28, 1920. The gravel averaged 13.66 cts. per yd. and costs were 6.99 cts. This company's operations grow, as in 1919 the yardage was 15,916,000 yd. of 19.49-ct. gravel, dug at a cost of 7.22 cts. The Natomas Co., with 11 boats, digs over 20,000,000 yd. for $1,770,000, of which $461,000 is profit. The Yukon Gold Co. operates 4 dredges, and digs over 500,000 yd. of 9-ct. gravel at a cost of 7.6 cts. These three companies alone contribute 37 per cent. of the State's gold yield.

The largest dredge in the world, one with 20-cu. ft. buckets, was started by the Estabrook Dredging Co. near Trinity Center during 1920. The boat was designed to dig 45 ft. below water. It can operate throughout the year, and can dig at least 400,000 cu. yd. per month. All the machinery is electrically driven, the total power of its motors being 1590 hp.[1] Another new enterprise was that of the Yankee Hill Co. in Stanislaus County.

Although it covers the subject in general, the paper[2] on gold dredging by W. H. Gardiner applies especially to California, as the author is connected with the Yuba Consolidated, which is the largest dredging company in the world. Dredging possibilities may easily be investigated and prospected—including the value and cost—with much accuracy, before operating is begun. Churn-drilling is a satisfactory method of prospecting placers. Mr. Gardiner thinks that when operating conditions are normal again, there will be a renewed interest in dredging projects.

A remarkable set of photographs, showing the Yuba River, dredges of this company at work, and the tailing piles, taken from an airplane at

[1] H. G. Peake, *Eng. Min. Jour.*, **109**, 1106 (1920).
[2] *Eng. Min. Jour.*, **110** 515 (1920).

a height of 6000 ft., was reproduced in the *Engineering and Mining Journal* of April 17, 1920.

Among the newer operations in hydraulic mining in California is the completion of the debris-restraining dam of the Elephant hydraulic mine, near Volcano, Amador County. This dam is 30 ft. high and 425 ft. long. Not many new dams of this kind were built in California in 1920, as few hydraulic mines have been opened and equipped. The old Cherokee mine, near Oroville, Butte County, once a famous hydraulic property, is to be reopened. The channel of this mine runs under Table Mountain. The El Dorado Exploration Co., Eldorado County, has discarded its steam-power plant at both mine and mill and has installed an electric plant. The old Delhi Mining Co., which owns extensive water-rights on the Middle Fork of the Yuba River, has put in a new hydro-electric power-plant, partly for its own use, but partly to supply power to the Pacific Gas & Electric Co. for general uses. At Meadow Lake, Nevada County, a mining camp that was virtually abandoned for 25 years, a cyanide plant has been built at the Excelsior mine—some of the other old mines will be reopened. The California Rand silver mine, in San Bernardino County, the most productive silver property in California, continued during 1920 to make shipments of high-grade ore to the Selby smelter. The Globe and Chloride-Bailey mines, near Dedrick, Trinity County, have been purchased by New York men and are being reopened. The Twenty-One Mining Co., at Alleghany, Sierra County, has sold its mining property to the Sixteen-to-One Mining Co., thus ending a long litigation. The Harvard mine, Tuolumne County, long owned by Boston men, has been sold to John Ferguson and associates, of Berkeley.[1]

A valuable hint was given mining engineers in California, and elsewhere for that matter, when W. J. Loring told[2] of the reopening of the Plymouth mine in Amador County, and the results. The mine had been idle for 24 years prior to 1911, when the present owners took charge. The old shaft was 1600 ft. deep. A 75-ft. winze below it showed 28 in. of $17 ore, and was followed to the 2000-ft. level. A zone of enrichment had been encountered below the 1600-ft. level, just as in other mines along the Mother Lode. From 2450 to 3050 ft. was another poor zone, followed by an enrichment at the latter depth, and all anxiety for the future of the mine was put aside. The shaft is to be deepened to 3700 ft. during 1921.

Following this article was a brief discussion[3] by the writer of this chapter, in which he mentioned that the Empire mine at Grass Valley had no ore between 1300 and 2100 ft.; the North Star had 600 ft. of barren vein below 1200 ft.; and the Central Eureka appeared to be exhausted at 3400 ft., but on sinking to 3700 ft. another shoot was revealed. Apparently basing their faith on such occurrences, the North Star is reopening two old mines, while the Allison Ranch, Idaho-Maryland, and Old Eureka are doing likewise. (The last-mentioned was shut down permanently in June, 1921. After spending about a million dollars, not enough ore was found to justify further operations.)

[1] U. S. Geol. Surv. [2] *Min. Sci. Press*, **121**, 771 (1920). [3] *Min. Sci. Press*, **122**, 6 (1921).

In the interview of A. DeWint Foote by T. A. Rickard[1] will be found some interesting facts relating to the North Star mine at Grass Valley and the Lightner near Alleghany. The former is now 6300 ft. deep on an average dip of 24°, equal to 2500 ft. vertically. The total yield is $18,000,000 from 1,600,000 tons. The Lightner may be classed as a "pocket" mine, and is again yielding rich ore. A few years ago, a space less than 100 ft. square contained gold worth $750,000. The total output is over $2,000,000.

In the interview of Albert Burch[2] will also be found much of value concerning California, particularly the Plymouth mine in Amador County

Unwatering of the Idaho-Maryland mine at Grass Valley was accomplished by means of an air-lift, according to G. J. Young.[3] The main shaft is about 1100 ft. deep, on an incline of 70°. A 10-in. pipe was used. With a 49-per cent. submergence the maximum capacity was 1450 gal. per min., with air at 97 lb. per sq. in. With 18-per cent. submergence and 60 lb. of air, the capacity fell to 250 gal. The average flow was 900 gal. per min. Some interesting details of pipe-supports or crossheads, measuring weir, etc., were given in this paper.

Abnormal conditions have resulted in irregular operation of the Belmont Shawmut mine, in Tuolumne County. The Tonopah Belmont Co. of Nevada controls the operating company, and has spent a large sum in developing and overhauling the mine. Reserves are over 400,000 tons, assaying $5 gold per ton. The geology and underground methods were described by A. B. Parsons,[4] who remarked that in order to mine such low-grade ore it was necessary to select the most economical system of mining. The main outlet is an 8 by 10-ft. crosscut adit, 1800 ft. long. A shaft was sunk below the tunnel, and in a station at this point is a hoist and crushing plant. Ore broken averages 3.84 tons per man underground. Direct costs are $1.79 per ton, and indirect 18 cts., a total of $1.97 per ton.

Colorado.—This State is the second largest gold producer and the fifth in silver. The last 10 years show the following:

Year.	Gold, Oz.	Value.	Silver, Oz.	Value.
1911	925,839	$19,138,800	7,331,200	$3,958,800
1912	899,222	18,588,562	8,212,070	5,050,423
1913	877,857	18,146,916	9,325,255	5,632,454
1914	961,845	19,883,105	8,796,065	4,864,224
1915	1,084,323	22,414,944	7,027,972	3,563,182
1916	928,075	19,185,000	7,551,761	4,967,900
1917	772,766	15,974,500	7,291,495	6,004,500
1918	615,558	12,724,700	6,900,266	6,765,435
1919	495,810	10,249,300	5,966,606	6,687,790
1920[5]	368,298	7,613,400	5,572,407	5,656,718

[1] *Min. Sci. Press*, **121**, 901 (1920).
[2] *Min. Sci. Press*, **121**, 299 (1920).
[3] *Eng. Min. Jour.*, **110**, 63 (1920).
[4] *Min. Sci. Press*, **121**, 619 (1920).
[5] Preliminary figures.

The principal events in gold and silver mining during 1920 included a decrease in the gold output of Cripple Creek from $5,796,000 to $4,500,000; general operations at a low ebb at Leadville; almost normal output of the dredges at Breckenridge; less metal from Clear Creek and Gilpin counties; and greater yields from the big mines in San Juan and San Miguel counties.

After four disastrous years, says G. E. Collins,[1] the close of 1920 finds the mining industry of Colorado in a more depressed condition than at any time in its history, though during December there were signs of an improvement, due to a surplus of skilled labor, the first since 1916. At Cripple Creek, regular dividends have been suspended. The Portland, Vindicator and Modoc have opened good ore to a depth of 2300 ft. The Cresson maintains its large output. To test the theory that the northeastern end of the Cripple Creek volcanic neck has been covered by a huge rock slide, diamond-drilling is being carried out to find out whether there are any orebodies beneath.

Georgia, Virginia, and the Carolinas.—Gold was found about 1830 in McDuffie County, Georgia, according to P. T. Bruhl.[2] This State has produced $18,000,000 in gold to date, $1,500,000 from the Columbia mine alone. Veins near the surface proved profitable, but the lower portions have not been systematically explored. The veins are in pre-Cambrian formations, which have been subjected to considerable shearing stresses. The industry lacks local support, due to the profitable nature of agriculture.

In Virginia, according to Marshall Haney,[3] gold was discovered in 1782, the first deposit in Orange County in 1830, and the first company was formed in 1832. The gold belt covers an area 20 to 30 miles wide and 200 miles long. Micaceous schists and gneisses are the principal rocks. Quartz is the chief gangue, with auriferous pyrite. Some veins are remarkably persistent, the Fisher, in Louisa County, having been opened for 5 miles and a depth of 250 ft.

In the Carolinas gold mining is not flourishing,[4] as the supply of free-milling ore is decreasing, and the lower-grade sulphide ore cannot be treated profitably at present.

The gold belt of the Southern States begins in Maryland and continues southwest through parts of Virginia, the Carolinas, Georgia, and Alabama, according to H. A. Megraw.[5] Recent development of mines in this region has been hindered by absence of a mining code, lack of mining experience, and failure to recognize limitations, that is, overestimating reserves and saddling mines with costly surface equipment.

[1] *Eng. Min. Jour.*, **111**, 167 (1921).
[2] *Eng. Min. Jour.*, **110**, 265 (1920).
[3] *Eng. Min. Jour.*, **110**, 264 (1920).
[4] *Eng. Min. Jour.*, **110**, 620 (1920).
[5] *Eng. Min. Jour.*, **110**, 938 (1920).

It is considered that under efficient management some properties could be operated profitably.

Idaho.—This State is an important silver but a small gold producer. The former metal is a by-product of lead and zinc ores, the latter is recovered almost equally by dredging and from some small gold mines. The yearly outputs for some time past are as follows:

Year.	Gold.		Silver.	
	Ounces.	Value.	Ounces.	Value.
1911	66,389	$1,372,387	8,196,136	$4,343,952
1912	66,816	1,381,214	8,294,745	5,101,268
1913	65,043	1,344,559	9,989,193	6,033,473
1914	57,431	1,152,315	12,479,516	6,901,172
1915	57,070	1,179,731	11,769,128	5,966,948
1916	51,195	1,058,300	11,570,399	7,611,500
1917	36,511	754,800	11,402,542	9,390,000
1918	33,930	701,400	9,396,009	9,212,411
1919	34,085	704,600	5,933,076	6,650,207
1920[1]	22,500	465,300	7,531,250	7,645,200

[1] Preliminary figures.

The largest gold producer in Idaho is the Gold Hill & Iowa mine at Quartzburg. This is followed by the Yukon Gold Co.'s dredge near Murray.

The gain in silver was due to greater activity most of the year at the lead and zinc mines, which operated at large capacity while prices were high. The Coeur d'Alene region produced 86 per cent. of the total silver. The leading contributors were the Hercules, Bunker Hill & Sullivan, Hecla, Morning, Gold Hunter, Tamarack, Callahan, and Caledonia.

If the present work at the old De Lamar and Trade Dollar mines, which yielded many millions up to several years ago, comes up to expectations, the gold and silver production of Idaho should show an appreciable advance within the next couple of years. These mines are in the Silver City district, on the west slope of the Owyhee Range, 60 miles south of Boise. Robert N. Bell, until the end of 1920 Inspector of Mines for Idaho, has briefly covered[1] past operations and the work now under way, especially beyond the faulted sections of the veins.

The Boise Basin district of Idaho, 25 miles north of Boise, has an area of 40 miles by 5 miles. The days of placer mining are gone, according to S. N. Ballard,[2] but numerous ditches and hydraulicked hillsides and gulches remain to show previous activity. Granite is the country rock. In it are many intrusions of diorite and rhyolite-porphyry dikes. The latter are worth study. They are found in countless parallel dikes, 30 to 40 ft. wide, and often only 100 to 200 ft. apart, and traceable for many

[1] *Eng. Min. Jour.*, **110**, 538 (1920).

[2] *Eng. Min. Jour.*, **109**, 881 (1920).

miles. The rhyolite porphyry is the only rock of economic value. The early-day miners did not recognize this, and they did much useless work in the granite and diorite, which has produced little of value. Only in the fissured zones in the quartz-porphyry dikes, or on the contacts where this porphyry is one wall, have persistent orebodies been found. The Gold Hill mine at Quartzburg has been operating profitably on two such zones to a depth of 500 ft. Gold and silver are associated with stibnite, sphalerite, and sometimes galena. Acting on this hypothesis, two more companies, long dormant, are developing fissure zones.

A settlement of the apex litigation of the Hecla Mining Co. has been made with the Federal Mining & Smelting Co., and negotiations have been concluded whereby the Marsh Mines Consolidated have released all claims and cancelled their lease of the O'Neil, Mono Fraction and Russel lode-mining claims.

Michigan.—In recent years the copper mines of this State have been yielding considerable quantities of silver, and Michigan now approaches Texas as a silver producer. Its output was 684,225 oz. in 1917, 491,939 oz. in 1918, 425,610 oz. in 1919, and 510,600 oz. in 1920. An abnormal copper yield in 1917 gave the extraordinary quantity of silver in that year.

Montana.—This is also a silver rather than a gold State, the former coming from the copper and zinc ores, and the latter from dredges and lode mines. The following table gives Montana's precious-metal yield for several years:

Year.	Gold.		Silver.	
	Ounces.	Value.	Ounces.	Value.
1910	180,462	$3,730,486	12,162,857	$6,567,942
1911	179,499	3,710,571	11,985,196	6,352,154
1912	175,371	3,625,235	12,731,638	7,829,957
1913	168,995	3,493,432	13,819,201	8,346,797
1914	200,446	4,143,600	12,016,460	6,645,100
1915	240,825	4,978,300	14,423,173	7,195,600
1916	209,386	4,328,400	14,046,054	9,240,100
1917	181,720	3,756,500	13,711,100	9,312,900
1918	158,704	3,280,700	16,378,263	16,058,232
1919	116,918	2,416,900	15,012,258	16,826,700
1920[1]	88,970	1,839,000	13,583,000	13,788,000

[1] Preliminary figures.

Gold extracted from silicious and iron ores was greatly reduced, and the output from dredges was somewhat less. The output of the copper mines, which produce most of the gold, did not reach normal, though it was greater than that of 1919. The Barnes King Development Co., which operates in Fergus and Lewis and Clark counties, produced much gold from silicious ores, but in the middle of the year its Piegan-Gloster

and North Moccasin mines were closed. The Southern Cross mine, in Deer Lodge County, which has been a large producer, was operated by the Anaconda company for only a short time in 1920. Another source of gold was the residue from the zinc ores of Butte, and a considerable amount also came from the Jardine mine, in Park County.

The mine output of silver decreased from 12,541,181 oz. in 1919 to 12,427,000 oz. in 1920, and the value of the output decreased from $14,046,123 to $13,551,000. Montana remained the leading silver producer of the United States, though Utah was a close second. In 1920, as in past years, most of this silver came from copper ores, but a large part of it was obtained by smelting residues from zinc ores, both those treated in the East and those leached at the electrolytic plant at Great Falls. The principal producers of silver were the Anaconda Copper Mining Co., Butte & Superior, Elm Orlu, Davis-Daly, North Butte, and East Butte, at Butte; the Granite-Bimetallic mine, at Philipsburg; and the Cascade Silver mine, at Neihart. A number of silver mines reported considerable development, and shipment of ores in the Neihart district of Cascade County; also in the Clancey and Basin-Wickes-Corbin districts of Jefferson County.

Nevada.—This State being one of the largest producers of gold and silver in the Union, its progress is followed closely. The output since 1908 is tabulated below:

Year.	Gold.		Silver.	
	Ounces.	Value.	Ounces.	Value.
1908	549,682	$11,362,941	9,508,464	$5,039,486
1909	785,608	16,239,963	10,981,061	5,711,152
1910	913,265	18,878,864	12,479,871	6,739,130
1911	880,106	18,193,397	13,184,601	6,987,839
1912	650,943	13,456,180	14,369,063	8,836,974
1913	570,589	11,795,130	16,090,083	9,718,410
1914	558,064	11,536,200	15,094,432	8,502,662
1915	574,874	11,883,700	14,453,085	7,210,500
1916	438,505	9,064,700	13,682,067	9,000,600
1917	334,894	6,922,900	11,441,000	9,312,900
1918	324,134	6,700,440	9,931,969	9,737,898
1919	225,384	4,659,100	7,045,395	7,896,972
1920[1]	171,970	3,554,900	7,392,690	7,504,500

[1] Preliminary figures.

In 1920, Nevada was fifth in the gold-producing and third in the silver-producing states.

The mine production of silver increased from 6,863,580 oz. in 1919 to 7,786,000 oz. in 1920, and in value from $7,687,210 to $8,480,000.[1] The large mines of the Tonopah district produced 4,970,000 oz. of silver in 1920, against 3,568,875 oz. in 1919, and 5,929,920 oz. in 1918. The largest producers of silver were the Tonopah Belmont,

[1] U. S. Geol. Surv.

West End, Tonopah Extension, Tonopah Mining, and Montana-Tonopah mines. Large quantities of silver were also produced by the Rochester Mines Co., Tonopah Divide, Spruce Monarch, Black Metals, Consolidated Virginia, Prince Consolidated, and Nevada Packard. The Comstock district produced 268,000 oz., and several properties at Rochester produced about 572,000 oz. In Churchill County a decided decrease resulted from the idleness of the Nevada Wonder mine.

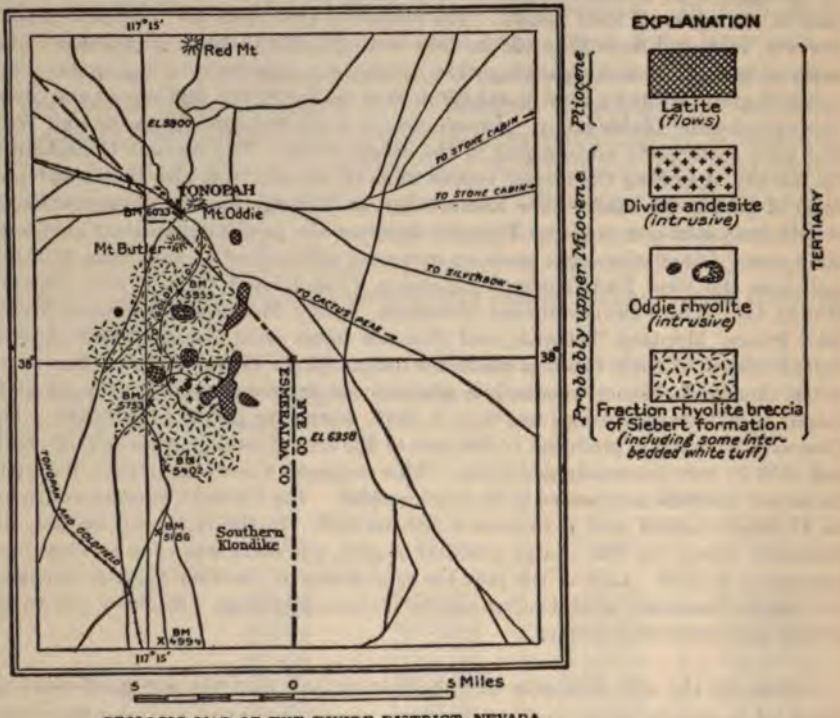
The Goldfield Consolidated property, for several years the largest gold producer in Nevada, was operated by the Goldfield Development Co., and a comparatively small production was reported. The ambitious scheme to treat 1000 tons of $6 ore daily fell through, after a large expenditure had been made. The mines are now under lease to a number of local people. The output of gold from the Tonopah district, however, increased from $771,804 in 1919 to $1,063,000 in 1920, on account of the larger output of the accompanying silver, which was favored by a high price. The Tonopah group treated a total of 355,000 tons of ore for $5,746, 000 in gold and silver. This excludes the Divide group. Developments in the Belmont Extension and West End were particularly encouraging in the deeper levels. The Nevada Consolidated Co., at Ely, operating the largest copper mine of Nevada, was also the largest producer of gold in the State. The Elkoro mine, at Jarbidge, was the largest producer of gold from gold ores, and the Tonopah Belmont Co. produced the most gold from silver ores. Other mines that made an output of gold valued at more than $150,000 each were the West End, Tonopah Extension, Consolidated Virginia, and Tonopah Mining Co. The Fairview Round Mountain, Round Mountain, Rochester Mines, Elko Prince, Montana Tonopah, and Florence mines were also producers of gold, though several of these failed to reach the output of the previous year. The mines of the Comstock district were active, especially in development work, though their output of gold was somewhat less than in 1919, when they produced $355,640. The Consolidated Virginia produced 17,700 tons of $20 ore. Developments at 2150, 2250, and 1650 ft. were extremely gratifying. This company was reorganized in 1921, and its output this year is expected to be much greater. The United Comstock is driving an 11,000-ft. tunnel and is to erect a 500-ton mill. In the Rochester district, the Rochester Mines Co. was a large producer of gold, and there was a fair increase over the output of 1919. Late in the year the new dredge of the Gold Canyon Dredging Co. began operations near Dayton on old Comstock tailings. Boulders and rough ground have been troublesome.

Most of the ore deposits of the Manhattan district are gold-bearing veins of a simple type and present no unusual features, but other ores enclosed in a single thin bed of limestone offer interesting problems, according to H. G. Ferguson.[1] Manhattan is 35 miles north of Tonopah. Ore was first discovered in 1905. The field has experienced booms and depressions. At present, save for shallow surface operations and exploration by the White Caps company to a depth of 800 ft., the district is dull. Ores occur in veins and as replacement deposits in limestone. Although near neighbors, the different mines in limestone show a wide diversity of mineralization. The White Caps limestone is considerably faulted. Gangue minerals are 56 per cent. SiO_2 as quartz, 7 CaO as calcite, 1.5 As, 9 Fe, and 8 per cent. S as arsenopyrite. The last is

[1] *Econ. Geol.*, **16**, 1 (1921).

auriferous. The ratio of gold to silver is 17 to 1. The metallurgy of this ore has been troublesome, and at last accounts the company was shipping ore for its arsenic content. During 1920, 1946 tons of ore yielded 670,000 lb. of arsenic and $38,000 of gold.

The boom in the Divide district, 6 miles south of Tonopah, abated considerably. Many of the properties are idle; others have taken an interest in outside properties; but the Tonopah Divide and Gold Zone



GEOLOGIC MAP OF THE DIVIDE DISTRICT, NEVADA.

FIG. 2.

mines produced ore. Output of the first was 11,043 tons valued at $317,217, equal to $28.72 per ton. The Gold Zone shipped 525 tons of $20 ore to Tonopah. The Divide mine was re-sampled during 1920, and the second estimate of about $1,250,000 of ore available was confirmed. The first estimate was over $9,000,000, if the orebody persisted. Recent developments to a depth of 1050 ft. have shown persistence in size and grade of the orebody.

In Bulletin 715-K (1921) of the U. S. Geological Survey, Adolph Knopf gave a general review of the Divide district. The prevailing rock

is the "Fraction" rhyolite-breccia. This is intruded by several stocks of the Oddie rhyolite and by a large mass of andesite. Later than all of these is a series of latite lava flows, which cap the highest peaks of the district. The orebodies are zones of fracturing and shearing in the rhyolite-breccia. Strictly speaking they are lodes, not veins. The principal silver-bearing mineral is cerargyrite (horn silver), which is commonly concentrated in rich masses along regular seams of sericite which traverse the lodes. The Tonopah Divide, the most important, yields ore averaging 25 oz. of silver and $2.50 gold per ton. The barrenness of the outcrops of this field is an outstanding feature. Mr. Knopf discusses the geology in detail, also results of some of the mines.

In reviewing the past year's results at Tonopah, the *Tonopah Miner* said that after 20 years the district has shown itself to be the greatest natural silver center in the world. The total output of silver and gold aggregates $140,000,000, of which considerable has been paid in dividends. It might be interposed here that although Tonopah has shown a decline, it is more stable than the rich ores of Cobalt, Ontario; but it has a rival in the Pachuca district of Hidalgo, Mexico. Quoting, this journal summarizes the position thus:

> The Tonopah Extension has proven its ore systems to a depth of 1760 ft. with every likelihood present that work from the next station at the 180-ft. level will find the downward extension of the Victor orebodies. The Tonopah Belmont and the Tonopah Mining Co., through intensive development campaigns, have shipped thousands of tons monthly to their respective milling plants and still have plenty of ore in sight; the West End Consolidated has made one of the most important finds in the history of Tonopah, at its California claim, on the northern slope of Mt. Brougher; the Midway Consolidated has its work well under way at the 1600-ft. level for the exploration of an immense block of trachyte, expecting to encounter rich ore-shoots that have been developed 300 ft. above; the California-Tonopah mine has become a steady producer of high-grade ore; the Halifax-Tonopah, besides having extracted big tonnages of ore from one shoot at the 1200-ft. level, is doing work of the greatest importance in proving up the extreme easterly side of the Tonopah ore zone; the Rescue Eula and the North Star have passed out of the assessment stage and have been steady shippers for months past; the Cash Boy, which has made intermittent shipments, promises to become an important addition to the list of Tonopah's producers; and the Jim Butler, the MacNamara, the Monarch Pittsburgh, the Tonopah "76" and others have continued steady work, and the first two named in this sentence have been included among the shipping properties of the Tonopah district.

Operating conditions at the Tonopah Extension mine were detailed by J. D. Dynan[1] at the October meeting of the Nevada Section of the American Institute of Mining and Metallurgical Engineers. Production, mostly since 1910, amounted to 15,267,216 oz. of silver and 156,241 oz.

[1] *Min. & Met.*, **170**, 26 (1921).

of gold, from 871,177 tons of ore. This gives an average recovery of 17.5 oz. of silver and 0.179 oz. of gold per ton. The average price received for silver since the beginning is 65.87 cts. per oz. The property consists of 647 acres. The Murray vein system, discovered in 1913, has been of the greatest importance as a producer. There are three main shafts, the No. 2, Victor, and McKane. Below the 950-ft. level of No. 2, a sub-shaft has been sunk to 1440 ft. Hoists at the surface and station are driven by 150- and 75-hp. motors, respectively. Two-ton skips operate in the sub-shaft. They dump into a bin, from which a 7½-hp. locomotive hauls 10 cars to No. 2 shaft. All ore from below the 1440-ft. level is hoisted through the Victor shaft, which is 1700 ft. deep. A 300-hp. hoist operates at this point. On the 1540- and 1760-ft. levels are electric locomotives. Two methods of timbering are in vogue, and care has to be exercised on account of a bad hanging wall. Stoping is either by the shrinkage system or by square-sets, if stopes are over 20 ft. wide. The Victor shaft makes up to 425 gal. of water per minute. Pumps have a capacity of 850 gal. per min. As the three shafts are connected, natural ventilation is relied upon; but in long drifts, motor-driven fans are used. Current operations consist of 1200 ft. of development, mining 10,000 tons of ore and employing 175 men per month.

The Rochester district had a fairly satisfactory year, more so since the Rochester Silver Corporation is in full working order again. The Nevada Packard is in financial difficulties.

In the Jarbidge district, the Long Hike mine of the Elkoro company had a good year. There was treated about 120,000 tons for $1,300,000, of which $700,000 was profit.

New Mexico.—This State reports a regular decline in precious metals, the total for 1920 being only a third of that in 1915. The industry depends on the Mogollon district and base-metal mines.

At Mogollon, the Mogollon Mines Co.'s concentration-cyanidation mill was operated steadily, with an increased output of gold and silver; but the Fanney mill, closed in April, 1919, was idle during 1920. The output of gold from the Aztec mine, at Baldy, Colfax County, was not so large as in 1919. The shipments of gold-bearing silicious copper ores from Lordsburg were large and equal to those of the preceding year. The gold properties at Nogal were idle. The Whiteoaks district continued to produce a small quantity of gold from amalgamating mills. Some large shipments of silver ore were made from Lake Valley during the early months of 1920. Several shipments of silver-manganese ore were made from Silver City, according to C. W. Henderson.

The following table exhibits the last 10 years' record of New Mexico;

Year.	Gold.		Silver.	
	Ounces.	Value.	Ounces.	Value.
1911	36,901	$762,808	1,354,540	$717,906
1912	37,947	784,446	1,536,701	945,071
1913	42,663	881,926	1,631,273	985,289
1914	58,974	1,219,100	1,777,445	982,927
1915	70,632	1,460,100	2,005,531	1,016,804
1916	65,306	1,350,000	1,729,917	1,138,000
1917	49,590	1,025,100	1,313,700	1,069,350
1918	33,237	687,080	773,662	758,545
1919	28,319	585,400	851,821	954,781
1920[1]	22,400	463,000	765,000	776,000

[1] Preliminary figures.

In Bulletin 715-L (1921) of the U. S. Geological Survey, H. G. Henderson in 34 pages (with maps) covers the Mogollon (mo-go-yohn) or Cooney

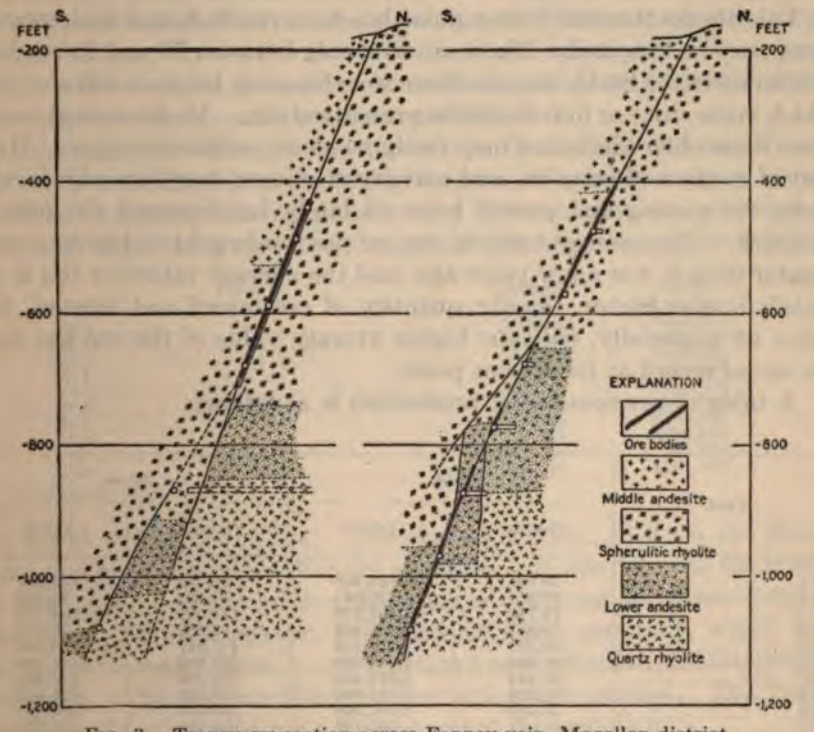


FIG. 3.—Transverse section across Fanney vein, Mogollon district.

district. Silver City, 85 miles southeast, is the nearest rail point. Rich silver-copper ore was found by James Cooney in August, 1875. Up to 1905 the output of silver, gold and copper was about $5,000,000; since 1904 to the end of 1917, definite statistics show $4,370,307 gold,

10,040,356 oz. of silver, 875,276 lb. of copper, and 11,355 lb. of lead, valued at $10,475,553, from 962,933 tons of ore. The total to 1921 approximated $18,000,000. The region is rugged, with several peaks over 10,000 ft. high. Veins are mostly well defined and form prominent outcrops. Ore-shoots are all in veins closely connected with faults. The principal rock is rhyolite. Quartz and calcite are the chief gangue minerals. Fluorite is plentiful. The main silver mineral is argentite. Copper sulphides predominate in some veins. Oxidation is shallow and irregular. Mr. Henderson briefly describes the mines. In the Little Fanney, which has produced nearly $5,000,000, ore has been exposed through a vertical distance of 1200 ft. and for 2700 ft. along the strike. The productive portion of the district covers only a comparatively small area. Elsewhere the veins, though well defined, are mostly barren.

Oregon.—A further small decline is recorded for 1920, yet Charles G. Yale thinks that the lowest point has been reached, and an improvement may be expected. There are now only between 70 and 80 productive mines in the State, whereas there were formerly between 150 and 200, which made three or four times the present output. Under normal conditions these older idle mines may easily be made productive again. High cost of wages and supplies, and scarcity of miners, together with lack of water for mining and power, have all lately handicapped the mining industry. The average value of the ore per ton in gold and silver is now greater than it was a few years ago, and the average value per ton in all metals is also higher. As the quantity of ore mined and treated has fallen off materially, only the higher average value of the ore has kept the metal record at its present point.

A table of precious-metal production is as follows:

Year.	Gold.		Silver.	
	Ounces.	Value.	Ounces.	Value.
1911	30,641	$633,407	45,221	$23,967
1912	37,251	770,041	57,081	35,105
1913	78,740	1,627,710	179,036	108,139
1914	76,887	1,589,400	142,552	78,831
1915	90,321	1,867,100	117,947	59,799
1916	91,985	1,901,500	221,887	146,000
1917	81,144	1,677,400	215,700	175,480
1918	61,228	1,265,700	129,150	126,626
1919	53,029	1,096,200	236,620	265,220
1920[1]	46,680	965,100	182,550	185,320

[1] Preliminary figures.

Placer gold has decreased in output owing to a decrease in the number of active hydraulic mines, lack of water, and smaller output by dredges. Among the deep mines some of those formerly very productive have

ceased operations. At present there are only three mines in the State that are yielding over $100,000 a year each. One of these is a deep gold mine (the Cornucopia), one a copper mine (the Iron Dyke), and the other a dredge property (the Powder River). General decrease in output of gold is shown in both the northeastern and southwestern counties of the State.

The most productive county in Oregon is Baker, and the next Grant. Baker County produces about 80 per cent. of the State's metallic output, almost all from the deep mines of the county. The output of the mines in Grant, Jackson, and Josephine counties increased, but there is little encouragement to report for the other counties. The principal placers of the State are worked by the hydraulic system, but the output of the dredges exceeds in value that of all other forms of placer mining combined. There are four gold dredges in Oregon, one of which was idle in 1920, and another worked only part time. The few large deep mines seemed to keep up or even exceed their normal output, but the owners of many of the smaller properties found it impossible to continue mining operations under prevailing adverse conditions.

South Dakota.—The gold output of the Black Hills region, which is the sole producing area of the State, has been remarkably uniform, as the table below shows, this being due to the Homestake mines, although in 1919 and 1920 this great mine, the greatest in America, and probably in

Year.	Ounces.	Value.
1910	261,334	$5,402,257
1911	359,904	7,439,874
1912	381,745	7,891,370
1913	354,070	7,319,294
1914	354,782	7,334,000
1915	358,145	7,403,500
1916	361,444	7,471,700
1917	357,619	7,392,600
1918	324,083	6,699,400
1919	255,889	5,289,700
1920[1]	203,243	4,201,400

[1] Preliminary estimate.

the world, suffered from fire. This started in Sept., 1919, on the 800-ft. level, and necessitated flooding the workings. It was not until the middle of 1920 that all of the mills—1020 stamps and cyanide plants—were in operation. It is of interest to record that this company, which used stamps for so many years, is now erecting a new reduction plant employing ball mills. The results will be watched with much interest. The Trojan was the only other gold mine that operated its cyanide mill.

Texas.—Gold production in this State is negligible, while the silver nearly all comes from the Presidio mine at Shafter, where a cyanide mill has operated for many years. Its yield has been very regular, being 524,000 oz. in 1920, 539,000 oz. in 1919, and about the same figure in previous years.

Utah.—Apart from one small gold mine, the Deer Trail near Marysvale, in Piute County, all of the gold and silver of this State come from copper, lead, and zinc mines, according to V. C. Heikes. Production was retarded during 1920 by increased freight-rates to smelters, also by continued high costs of mining and treatment operations. The last 10 years' production of this State are given below.

Year.	Gold.		Silver.	
	Ounces.	Value.	Ounces.	Value.
1911	227,217	$4,696,998	12,473,787	$6,611,107
1912	206,380	4,265,851	13,835,903	8,509,070
1913	172,480	3,565,229	13,084,835	7,903,230
1914	163,362	3,377,000	11,154,916	6,168,669
1915	189,045	3,907,900	13,073,471	6,522,200
1916	186,679	3,859,000	13,545,802	8,911,000
1917	175,133	3,620,300	14,315,300	11,652,650
1918	152,526	3,153,000	13,492,555	13,228,911
1919	109,660	2,266,900	12,542,620	14,058,650
1920	100,440	2,076,400	11,564,150	11,739,120

[1] Preliminary estimate.

As before mentioned, Utah is essentially a base-metal State, yet there are scattered gold deposits, and a study of a most important Professional Paper, No. 111, of the U. S. Geological Survey, entitled "The Ore Deposits of Utah," of 672 pages, by B. S. Butler, G. F. Loughlin, V. C. Heikes, and others, issued during 1920, should be profitable. There is specific mention of a number of gold veins. As to silver, many of the Utah lead deposits are highly productive.

Washington.—A drop of 44 per cent. in gold and 25 per cent. in silver was reported for 1920. The totals were $149,000 and 183,000 oz., compared with $236,000 and 258,000 oz. in 1919. The Republic district of Ferry County shipped 10,200 tons of silicious gold ore, against 25,500 in 1919. The Quilp was the largest producer. This group is more or less dependent upon the requirements of the Northport and Trail smelters. Most of the silver comes from copper ores, the United Silver mine in the Chewelah district of Stevens County contributing the bulk of this metal.

In an article[1] discussing dominant features controlling ore deposits in Washington, E. N. Patty states that practically all of the deposits show evidence of direct association with batholithic intrusions of granitic rocks. These batholiths are the source of almost the entire metal resources of the State. The gold-silver ores of the Republic district are excepted, as they represent a distinctly different period of mineralization. In northern Okanogan County there are several promising disseminated low-grade deposits of gold and copper, but not enough work has been done to form a definite opinion as to their possibilities.

[1] *Eng. Min. Jour.*, 110, 467 (1920).

Gold and Silver Mining in Foreign Countries

Africa

This continent contributed 55 per cent. of the world's gold in 1920, and will continue to be the main supply for years to come.

Belgian Congo.—An almost unknown, yet steadily increasing gold producer, is the Kilo State Mines. These are situated in the northeast part of the Congo, and were discovered in 1902. Communication with the outside is by wireless and a 125-kilometer motor-road to Kasenyi, on Lake Albert. Two railways are projected. Production has been as follows:

Year.	Gold, Oz.	Year.	Gold, Oz.	Year.	Gold, Oz.
1905	675	1911	20,543	1917	57,615
1906	6,815	1912	22,505	1918	67,180
1907	10,545	1913	.....	1919	80,000[1]
1908	9,998	1914	33,675	1920	100,000[1]
1909	21,090	1915	52,196		
1910	28,163	1916	52,685		

[1] Estimated.

A nugget weighing 145 oz. was found early in 1920.

According to S. H. Ball and M. K. Shaler, who covered[1] the region fully, gold is an important product of the Belgian Congo. To the end of 1919, placers produced nearly $17,000,000 (U. S.) of gold. These are in the northeastern part of the Colony, 100 miles apart, and are called the Kilo and Moto. The country rock at Kilo is diorite, schist, syenite, and granite. In 1918, the gravel averaged $2.17 per yd. Costs were $1.25 per yd. Lodes have also been developed at Kilo, reserves being over 400,000 long tons worth $7.50 per ton. At Moto the country rocks are granite, diorite, and hematitic schist. In the Ruwe mine, about 800 miles southwest of the Kilo field, is an ore-shoot 1400 ft. long and 7½ ft. wide, averaging $14 per ton in gold, platinum, and silver.

Egypt.—The production of gold in Egypt has never been large in recent times. It reached 7096 fine oz. in 1915 and fell to 2856 oz. in 1918, owing to the increase in working costs and the difficulty of obtaining supplies, which resulted in the closing down of most of the small mines previously producing. At the end of 1919 regular production of gold ceased, and only one prospecting party was at work. The gold of Egypt occurs in quartz veins. The ore is free-milling, and gives good extraction by amalgamation and cyanide. All the occurrences now known were at one time worked by the ancients. They are small, but often contain exceptionally rich patches. The question of transport

[1] *Eng. Min. Jour.*, **110**, 804 (1920).

and water-supply for Egyptian gold mines is complicated by their isolated positions in the desert, but these difficulties are not greater than those which have been successfully overcome in other countries, according to the Department of Mines.

Rhodesia.—This Colony produced 550,000 oz. of gold last year. About 1,000,000 tons of ore is milled, including 180,000 of copper-gold ore at the Falcon. The Shamva is by far the greatest producer, treating over 500,000 tons of 21s. ($5) ore per annum. The Lonely Reef yields about 20s. ($4.80) ore. Generally speaking, Rhodesian mines are low grade.

The Globe & Phoenix averages 5700 tons of 35s. ($8.40) ore per month, averaging 2 per cent. of stibnite, with both fine and coarse gold. Assaying methods are described[1] by H. R. Edmands, who introduced several innovations devised by him in Western Australia. A small ball mill is used for crushing samples, and gives uniform results. A reverberatory furnace, using wood, or coal, or both, is employed for fusion and cupellation. No muffle is needed, which is unique in assaying.

The table below shows the progress of this country:

Year.	Value.	Year.	Value.
1899	£230,000	1910	£2,568,000
1900	340,000	1911	2,648,000
1901	640,000	1912	2,707,000
1902	744,000	1913	2,903,000
1903	870,000	1914	3,530,000
1904	1,000,000	1915	3,823,000
1905	1,500,000	1916	3,889,000
1906	2,060,000	1917	3,495,000
1907	2,170,000	1918	2,652,000
1908	2,525,000	1919	2,499,500
1909	2,622,000	1920	2,340,000

Transvaal.—In spite of four mines being shut down for good, this State reported a decrease of under 2 per cent. during 1920. The gold premium was most helpful of course to the low-grade mines. The future of the field is dependent upon the Far East Rand, where eight mines contain actually developed reserves of 35,177,515 tons, valued at £77,000,000 gross, according to H. F. Marriott.[2] The New Modder alone has 20,000,000 tons. Employment is given to 22,000 whites and 175,000 Kaffirs.

The Chamber of Mines estimates the gold value in 1920 as £43,133,000 based on the fine-gold value plus the average premium; but the Union Mines Department places the total at £34,654,000, which is just the normal value per ounce.[3]

[1] *Jour. Chem. Met. Min. Soc. So. Afr.*, April, 1920.
[2] *Eng. Min. Jour.*, **111**, 190 (1921).
[3] A. Cooper Key, *Eng. Min. Jour.*, **111**, 663 (1921).

TRANSVAAL GOLD PRODUCTION

Witwatersrand District

Year.	Tons Milled.	Value.	Value per Ton Milled, Shillings.	Outside Mines, Value.	Total Value for Transvaal.	Dividends.
1884–89	1,000,000	£2,440,000	48.8	£238,231	£2,678,231	
1890	730,000	1,735,491	47.4	134,154	1,869,645	
1891	1,154,144	2,556,328	44.2	367,977	2,924,305	
1892	1,979,354	4,297,610	43.3	243,461	4,541,071	
1893	2,203,704	5,187,206	47.0	293,292	5,480,498	
1894	2,830,885	6,963,100	49.2	704,052	7,667,152	
1895	3,456,575	7,840,770	45.2	728,776	8,569,555	
1896	4,011,697	7,864,341	39.2	739,480	8,603,821	
1897	5,325,355	10,583,616	39.7	1,070,109	11,653,725	
1898	7,331,446	15,141,376	41.3	1,099,254	16,240,630	
1899	6,872,750	15,067,473	48.8	661,220	15,728,693	
1900 Boer War	459,018	1,510,131	65.8	.....	1,510,131	
1901 Boer War	412,006	1,014,687	49.2	81,364	1,096,151	£100,059,205
1902	3,416,813	7,179,074	42.0	74,591	7,253,665	
1903	6,105,016	12,146,307	39.8	442,941	12,589,248	
1904	8,058,295	15,539,219	38.5	515,590	16,054,809	
1905	11,160,422	19,991,658	35.8	810,416	20,802,074	
1906	13,571,554	23,615,400	34.8	964,587	24,579,987	
1907	15,523,229	26,421,837	34.0	981,901	27,403,738	
1908	18,196,589	28,810,393	31.6	1,147,217	29,957,610	
1909	20,543,759	29,900,359	29.1	1,025,429	30,925,788	
1910	21,432,541	30,703,912	28.5	1,297,823	32,001,735	
1911	23,888,258	33,543,479	28.1	1,498,006	35,041,485	
1912	25,486,361	37,182,796	29.2	1,574,765	38,757,560	
1913	25,628,432	35,812,605	27.8	1,545,435	37,358,040	
1914 World War	25,701,954	34,124,434	26.5	1,463,641	35,588,075	£8,073,436
1915 World War	28,314,579	37,264,992	26.3	1,362,469	38,627,461	7,619,416
1916 World War	28,525,252	38,107,909	26.7	1,377,025	39,484,934	7,095,066
1917 World War	27,251,960	37,017,633	27.1	1,306,288	38,323,921	6,556,188
1918 World War	24,922,763	34,823,017	27.9	945,671	35,768,688	5,330,966
1919	24,043,638	34,454,478	28.7	929,496	35,383,974	6,287,200[1]
1920	24,836,000	33,979,000	27.4	885,000	34,864,000	8,314,300[1]

[1] Increase due to exchange premium on gold sold in open market.

Concerning the Union Government's expected profits from the Far East Rand, E. M. Weston showed[1] that seven leases will bring in £38,520,000 during the next 20 years or so. The present leases are as follows:

Operating Company.	Claims (1½ Acres Each).	Govt. Share of Profits.
Brakpan	1,812	£2,600,000
Cragie	31	5,000
Govt. Gold Mining Areas	2,633	18,400,000
Modder East	651	250,000
New State Areas	2,055	8,400,000
Spring Mines	2,236	5,600,000
West Springs	2,236	6,200,000

There is yet a large area of ground that is probably of great potential value, but the Government calls for tenders only when it thinks that capital is available from several sources, insuring competition.

In discussing the gold premium, the *South African Mining Journal* of Oct. 9, 1920, stated that during the past 18 months it had warned the Rand of the real significance of the premium and the low-grade mines. The *Journal* is also backed by the views of Sir Evelyn Wallers, chairman of the Chamber of Mines of the Transvaal. In 1919, he pointed out that

[1] *Eng. Min. Jour.*, **109**, 612 (1920).

the 21 lowest-grade mines on the Rand had worked during the preceding quarter at an average loss of 0.6d. (1.2 cts. normal exchange) per ton. These mines employed 10,500 Europeans, produced over £1,000,000 of gold each month, and spent annually £6,500,000 in wages and salaries, and £4,800,000 in stores. The Low-Grade Mines Commission (report made in May, 1920) found that the danger of some of these mines closing was imminent and that some of them, once closed down, would in all probability never be reopened.

The relief afforded by the gold premium is necessarily temporary. The problem of the low-grade mines is thus not solved, but merely postponed; and it will recur in an even more acute form, since the normal life of each mine will have been shortened by the length of the interval. In 1914, the Far East Rand contributed only about 26 per cent. of the total dividends paid in that year; in 1918 it contributed about 62 per cent. In 1919 the dividends paid by the remainder of the Reef amounted to only £2,393,703, which though a slight improvement on the £1,929,430 of 1918, still leaves very insufficient margin of safety. To show how narrow the margin is, with working costs at their present figure, sixteen of the mines now at work, employing between them about 5800 Europeans, will, when gold drops to 100s. per oz., be making a loss. When it drops to 90s., the number of mines affected will be increased to 26 and the number of European employees to nearly 12,000; and, when gold returns to its normal price of 85s. 31 mines, with a total of about 14,400 European employees, will no longer pay for working. These figures are for working costs only; no allowance has been made for debenture and similar charges. These are unpleasant figures and clearly indicate a position that employer and employed must avert by every means in their power.

The Low-Grade Mines Commission advocated recruiting colored labor from north of 22° south latitude, and the free sale of gold in India, the latter to save the 7-per cent. discount exacted by banks for marketing Rand gold. The elimination of group control would not reduce costs, as had been frequently suggested; and a government subsidy was not recommended. No action had been taken up to 1921.

The following comparative table reflects the increase in white and black-labor costs, in general commodities, and the decrease in efficiency:

	First Half of 1914.			First Quarter of 1919.		
	Per Ton Milled.					
White salaries and wages	5s.	1d.	($ 1.22)[1]	7s.	1d.	($ 1.70)[1]
Native wages	3	9	(0.90)	4	2	(1.00)
Stores and materials	5	5	(1.30)	7	10	(1.80)
Administration	0	5.7	(0.11)	0	6.3	(0.13)
Gold realization	0	3.1	(0.06)	0	6.3	(0.13)
Cost of development per foot	54	1	(12.98)	81	5	(19.54)
Tons handled per white employee	115.2	0	.....	101.2	0	.....
Tons handled per native employee	15.5	0	.....	13.7	0	.....

[1] Normal exchange.

The following table shows how exchange rates and a lesser price for gold diminished the revenue of the mines during the first half of 1920:

	Price of Gold per Fine Oz.	Realization Charges per Fine Oz.	Net Value per Fine Oz.
January	£5 7 6	1/0	£5 6 6
February	5 10 6	5/0	5 5 5
March	5 5 0	6/3	4 18 9
April	5 2 6	7/6	4 15 0
May	5 5 0	8/9	4 16 3
June	5 2 6	7/0	4 15 6

During the whole of 1920, the total premium approximated £10,000,000.

Asia

Although this continent covers an area of about 14,000,000 sq. mi. and has a population of nearly 900,000,000 people, the present gold and silver output is small, that is, when compared with other regions. Definite figures are obtainable early from India and Korea; the remaining countries are very slow in publishing such data. Normally Asia, including Siberia, produces over $35,000,000 of gold and 9,000,000 oz. of silver, but yields from the Russian regions are now at low ebb.

Asia Minor.—Basing his theory on the historic past and modern geologic observations, Leon Dominian[1] thinks that the source of the placer gold is not depleted in the Asiatic Near East, and with the introduction of modern machinery and methods, gold production should increase. It is said that near Astyra, not far south of Gallipoli, Tertiary igneous rocks have been detected in which there are rhyolite, andesite, and basalt flows, remarkably similar to those in Nevada.

China.—A little information concerning mining in China, as much as is available, may be obtained by perusing the *Far Eastern Review*, published in Shanghai, and *Asia*, published in New York. Both are monthlies of considerable merit. Published data may also be increased by the monthly journal to be issued by the newly formed Association of Chinese and American Engineers in Pekin. This body is supported by the Chinese Government.

The estimated production of gold in 1919 was 159,000 oz., and of silver, 65,000 oz. Apparently these are the latest figures obtainable.

"Problems Fundamental to Mining Enterprise in the Far East" was the title of an address given by H. Foster Bain, now director of the U. S. Bureau of Mines, and who was in the Orient for about three years, before the New York section of the Mining and Metallurgical Society of

[1] *Eng. Min. Jour.*, **109**, 309 (1920).

America on Dec. 29, 1920. Mr. Bain presented a general review of conditions. Among other things he stated that the Far East is not a rich country. It is poor as compared with Europe and America. Trade must be a give and take. The countries are largely self-contained. A selling campaign necessitates a campaign to increase buying power. Successful development of trade depends on thorough study of local conditions and customs, and primary rather than secondary contact through trading companies. The Chinese do not produce enough mineral to supply their own requirements. In developing new industries Mr. Bain showed how difficult it would be to induce the working population to change from habitual employments to new ones. The seasonal requirements of the agricultural industry were exceedingly difficult to overcome. Under the existing sociological conditions there is little incentive to individualism, and industry must contend with closely knit family groups. In addition, there is the general lack of sanitation and the fact that the climate over considerable areas is a tropical one. European powers that have established themselves in the Far East hold on to what each has for the benefit of its own nationals, and it is a fact that many countries are not freely open to aliens. The mineral resources of China, according to Mr. Bain, have been overrated. Many of the mines are small, and the mining conditions in general are comparable to those which prevail in the southeastern part of the United States. The mineral production is small and is made under unusual transportation and local conditions. Foundries and machine-shops are essential parts of mining plants. While the day's pay is small, other factors have to be considered and these in themselves are more important than day's pay. Labor is largely employed under a contract system; workers are indifferent to accuracy, as there is no standardization of local weights and measures; and efficiency is low. Transportation is difficult and costs high. Absence of a common law for both native and foreign, exchange difficulties and local customs are matters of no mean moment. Mr. Bain is of the opinion that the Far East is no place for the shoe-string promoter, but that well organized companies would find it a remunerative field. His views corroborate closely others (Herbert Hoover, Pope Yeatman, W. H. Shockley, Collins, and LeClerc) that have discussed the Orient, and been mentioned from time to time in MINERAL INDUSTRY.

On the other hand, R. A. White, in *The Transit*, an annual of the College of Applied Science of the University of Iowa, considers that China offers perhaps the greatest opportunity for the engineer of any country on the earth. At the present time, he says, the ground is being laid for what may develop into enormous works in a multitude of fields, including mining. Again, T. T. Read, who lived for several years in China,

said[1] that there are many difficulties to contend with; there are small possibilities of discovering extensive ore deposits; there are really no mining laws; and development is hindered by lack of transportation facilities.

Dutch East Indies.—Gold is found in Borneo, Celebes, and Sumatra in alluvial, beach, Tertiary gravel, and vein deposits.[2] Alluvial mining and dredging have met with little success. Near Benkolen in Sumatra are three good mines, including Redjang Lebang. Modern equipment is employed. The ratio of silver to gold is about4 to 1. In the northern peninsula of the Celebes is another gold region with three producers. There is a third area being exploited in Central Sumatra.

It is generally impossible to obtain figures of gold production in this region until late in the year. The following table gives the total production of gold in florins (the normal exchange value of the florin is $0.402) from 1911 to 1918, inclusive:

Year.	Sumatra.	Celebes.	Year.	Sumatra.	Celebes.
1911	6,434,500	1,615,000	1915	4,116,000	1,135,000
1912	5,638,000	1,425,500	1916	2,933,000	1,035,000
1913	5,047,000	760,000	1917	4,242,500	830,100
1914	6,775,700	1,224,300	1918	3,726,500	842,700

India.—In round numbers, gold production of this country fell off 100,000 oz. since 1916, to the 446,000 oz. of 1920. In spite of continual exploration at depth (4000 to 5000 ft.) the gold content of the veins decreases; yet the past has been a wonderful record. An historical review of mining in the State of Mysore was given by E. W. T. Slater,[3] who considers the Kolar field one of the most interesting places in India and among the most important goldfields of the world. No great hardships were experienced in developing this region, yet there have been many romantic incidents. The auriferous veins lie in a narrow belt of hornblende schists, which are older than the gneiss which cuts off the schists on both sides and below. Faulting is closely studied. Mining is expected to continue for at least another 20 or 30 years. Ore treatment is extremely simple.

The table following shows how remarkably even has been the output of this country. The Kolar goldfield in Mysore accounts for over 90 per cent., and the mines are all under one control.

[1] *Eng. Min. Jour.*, **110**, 298 (1920).
[2] Year Book of Netherlands East Indies and Bull. of Govt. Dept. of Agriculture, etc.
[3] *Eng. Min. Jour.*, **110**, 302 (1920).

Year.	Value.	Year.	Value.
1891	£516,000	1906	£2,500,000
1892	620,000	1907	2,160,000
1893	870,000	1908	2,158,000
1894	600,000	1909	2,167,000
1895	730,000	1910	2,105,000
1896	1,200,000	1911	2,150,000
1897	1,500,000	1912	2,265,000
1898	1,620,000	1913	2,300,000
1899	1,740,000	1914	2,340,000
1900	1,930,000	1915	2,370,000
1901	1,960,000	1916	2,300,000
1902	2,100,000	1917	2,214,000
1903	2,380,000	1918	2,080,000
1904	2,440,000	1919	1,950,000
1905	2,490,000	1920	1,890,000

Indo-China.—In this French colony there are several gold deposits, according to the *Far Eastern Review* for November, 1919, which abstracted the notes from the bulletin of the Comité d'Assistance aux Travailleurs Indo-Chinais. In Annam is the Bong-Mieu gold mine, the only one operated in the colony by Europeans. A good deal of placer work has been done in the vicinity. The vein is in gneiss, and the ore carries galena and arsenical pyrite. An 80-ton concentrating and cyaniding plant is at work.

Japan.—Nothing of special import has been chronicled from this country, where gold and silver are mostly a by-product of the copper and lead mines. If anything, production would be lower in 1920 than in 1919.

Korea.—Production is maintained in this country, principally by the Oriental Consolidated and Seoul Mining companies, so well and favorably known. Mining is, indeed, with the exception of farming, Korea's greatest industry; yet the Japanese appear to have established no schools which specialize in mining engineering, according to R. H. Ritter[1] in discussing industrial education in Korea. An explanation may be found in the fact that the majority of these mines are held by European interests, which had a firm title long before Japan secured control of the peninsula. European managers are much more anxious to use as foremen, gangsters or engineers, Koreans who were trained in Japan than are the Japanese themselves, for, as is quite natural, the Japanese capitalists prefer to give employment to their fellow countrymen. As a rule only European and American firms employ foreign-trained Koreans. A significant fact is that the Government now forbids Koreans to study in America or Europe, whether in the fields of commerce, the professions, or industry. It is impossible to secure a passport for such a purpose.

[1] *North American Review*, Oct., 1920.

AUSTRALASIA

The Commonwealth of Australia and Dominion of New Zealand show a decrease of 360 per cent. in gold production since the year 1903. There is no arresting the decline.

Year.	Value.	Year.	Value.
1892	£6,842,044	1907	£15,542,599
1893	7,128,610	1908	15,063,778
1894	8,282,241	1909	14,711,409
1895	8,870,193	1910	13,450,168
1896	8,995,624	1911	12,368,406
1897	10,856,835	1912	11,225,059
1898	11,791,724	1913	10,836,072
1899	16,174,426	1914	9,625,316
1900	15,141,478	1915	10,090,339 [1]
1901	15,943,761	1916	8,432,000
1902	17,032,402	1917	7,490,000
1903	18,332,515	1918	6,416,000
1904	17,984,838	1919	5,235,000
1905	17,644,846	1920	4,958,000
1906	16,901,649		

[1] Gain due to New Zealand exporting gold held on account of war.

PRODUCTION OF GOLD IN AUSTRALASIA, BY STATES
(In fine ounces)

State.	1913.	1914.	1915.	1916.	1917.	1918.	1919.	1920.
New South Wales	149,657	124,507	132,498	108,144	85,092	87,045	65,838	48,907
Northern Territory	(e) 4,600	(e) 4,500	2,532	(e) 1,540	(e) 1,500	525	500	800
Papua (New Guinea)	.....	.....	.....	.....	.....	8,707	11,919	11,000
Queensland	265,735	248,395	249,360	215,162	179,305	133,571	121,030	115,230
South Australia	6,556	6,258	6,081	7,769	7,145	6,189	3,224	1,697
Tasmania	33,440	26,243	18,547	15,790	14,496	10,529	7,686	6,246
Victoria	434,932	409,706	329,068	256,643	204,708	158,827	135,427	152,972
West Australia	1,314,044	1,232,974	1,210,109	1,061,398	970,317	876,510	724,053	617,842
Commonwealth	2,209,700	2,053,402	1,948,372	1,666,446	1,462,563	1,281,903	1,069,677	954,694
New Zealand	343,627	227,954	422,825	292,620	218,624	169,350	162,587	212,363
Total Australasia	2,553,327	2,281,356	2,371,347	1,959,066	1,681,187	1,451,253	1,232,264	1,167,057

(e) Estimated.

The one bright spot in gold mining in Australia was the selling of the metal in the open market, the premium realized balancing a depreciated sterling exchange. From February, 1919, to October, 1920, the Gold Producers' Association sold £6,579,150 ($31,908,889) and the total was expected to be £7,340,000 ($35,235,000) by the end of 1920. This was sold in the Orient. In 1920, 164,700 oz. was sold in America for $4,646,160, giving a premium of $1,244,160. Distribution of premiums amounted to £627,330 in 1919, and £977,316 in 1920, a total of £1,604,646.

New South Wales.—According to a graph prepared by the Government Department of Mines, gold production is now only 16 per cent. of what it was in 1898. The graph shows a value of £1,600,000 for that

year. Then it dropped to £750,000 in 1901 and 1902. To 1905 there was a gradual gain to £1,200,000, after which the yield fell steadily to about £250,000 in 1920. These figures would indicate that the industry is at a low ebb, partly due to the closing of copper mines and intermittent operations at the Mt. Boppy gold mine, the principal producer.

As to silver, the Broken Hill field was closed by labor troubles from May, 1919, to November, 1920, so that the output for 1920 will be almost negligible.

Queensland.—This State is on a par with New South Wales and Victoria, in that its once famous fields are about exhausted, and only for the gold from Mt. Morgan and other copper mines the yield would be very small.

There was a slight revival in the Normanby field, 44 miles south of Bowen, but nothing of great size has developed so far. This district has been idle since 1908.

Victoria.—Bendigo is the center of attraction, directed by the profitable operations of the Bendigo Amalgamated, as before stated, a consolidation of about 40 properties. During the second half of 1920 the output was £129,387 from 50,692 tons of ore, plus £65,090 from gold premium. The profit was £70,500. The company had £150,000 in hand, and proposed to enter the rubber business, which is peculiar, many shareholders thinking so, too.

A brief paper[1] by Waldemar Lindgren discusses vein filling at Bendigo. This really follows the paper and discussions[2] by Stilwell, Bateman, and Taber. Mr. Lindgren could not share the opinion originated by E. J. Dunn of Victoria that the opening of the veins was due to pressure of the crystallizing quartz.

Western Australia.—The principal features of gold mining in this State during 1920 were a further decrease in output; continued development in the new field of Hampton Plains; active exploration in the Ives and Broad Arrow districts, south and north of Kalgoorlie, respectively; and two strikes of wood-cutters, causing a complete shut-down of the mines at Kalgoorlie for several weeks. Some of the large properties on the "Golden Mile" at Kalgoorlie have found it difficult to make ends meet, but it will be more so during 1921, as on Jan. 1 the Arbitration Court awarded a minimum wage of 16s. ($3.84) per shift. Previously the wage was 12s. 6d. ($3).

In May, 1920, the Australian Workers' Union asked the Government to investigate the air underground in the deep mines at Kalgoorlie. The assistant inspector of explosives, T. N. Kirton, accompanied by an

[1] *Econ. Geol.*, **15**, 312 (1920).

[2] *Econ. Geol.*, **13**, 100, 222, 538 (1918).

inspector of mines and a Union official, made the examination. The report was filed in August. In the nine mines, there were a total of 668 men employed on day shift; they used 937 lb. of explosives, and the volume of air passing through aggregated 373,000 cu. ft. The number of men is small, so is the quantity of explosives consumed, while the amount of air is enormous, and miners have nothing to fear from the atmospheric condition of the mines. The workings were reported to be remarkably free from dust.

By April, 1920, according to published maps[1] of Blocks 48 and 50 of Hampton Plains, there were 49 and 96 lessees or option-holders, respectively, many of them organized as companies. At regular intervals in these groups, Hampton Properties, Ltd., owner of the tract, has reserve blocks. The new field was described by T. Butement[2] of the Kalgoorlie School of Mines. In addition to a review of the various opinions concerning the geology, Mr. Butement gave brief descriptions of the half-dozen principal operators. The field was also visited by P. G. Tait in August. He said[3] that, judged by the share-market, the boom had collapsed, the majority of the companies floated having failed to justify their existence; others had gone into liquidation; while others were spending their cash in exploiting outside districts. Apart from these facts, a large area has been prospected, and in a few cases encouraging prospects had rewarded the companies. The Hampton Celebration had a 200-ft. shaft, and a wide lode of $5 ore had been developed. The Mutooroo was down 130 ft., and a 310-ton shipment to Kalgoorlie yielded 47 dwt. per ton. The White Hope had opened sulphide ore, while the Golden Hope, Hampton Gold, and Hampton Properties had met with fair results.

One of the geologists who studied Hampton Plains, and who is frequently quoted, is C. S. Honman. He considers[4] that geologic conditions warrant systematic search for new lodes, and there is no reason why those already discovered should not extend downward at least as deep as the Kalgoorlie mines, 19 miles distant, are now being worked.

New Zealand.—Mining in the Dominion during 1920 was hampered by strikes and shortage of coal, also a general "go slow" policy. The Waihi company prepared No. 12 level for the development of the whole lode system. It installed a large pump early in 1921. The Waihi Grand Junction is opening its main lode on No. 9 level. The Talisman at Karangahake continued sinking its No. 16 winze on the main lode, but metal contents did not improve, and early in 1921 work was stopped permanently. The total output has been £2,951,300 from about 400,000 tons of ore. Dividends have amounted to £1,151,100.

[1] *Chem. Eng. Min. Rev.*, **12**, 262 (1920).
[2] *Chem. Eng. Min. Rev.*, **12**, 281 (1920).
[3] *Chem. Eng. Min. Rev.*, **12**, 441 (1920).
[4] *Indus. Austr. Min. Stand.*, Dec. 18, 1919.

The Waihi gold mine is the bright spot in New Zealand mining. The company's finances have become so healthy, the result of 30 years of careful and profitable operations, that the capital was reduced by 50 per cent. during 1921, the amount being returned to shareholders as a dividend. Net investments at the end of 1920 totaled, with cash, supplies, and the hydro-electric plant bonds owing by the Dominion Government, £850,000. Dividends to the middle of 1921 approximate £6,000,000. Production since 1890 amounts to £13,000,000. These are big figures. Although operations in 1920 were curtailed by strike, the yield was 48,500 oz. of gold and 289,000 oz. of silver, valued at £340,000, from 159,000 tons of ore. Extraction is remarkably even and good, hardly varying from 91 per cent. during the last six years. The mine is now 1600 ft. deep, but recent developments have not been very satisfactory. The daily output of water is nearly 1,000,000 gal. However, the 460,000 tons of ore in reserve, and future possibilities, should give a number of profitable years.

The Grand Junction mine adjoining has 90,000 tons of ore in reserve. The output last year was 66,000 tons of 32s. ($7.70) ore, and a deficit of £18,400 was reported.

In the South Island, the Blackwater and Progress mines continue to produce 25,000 and 16,000 tons of ore, yielding £52,000 and £20,000 in gold, respectively, per annum. The former made a profit of £10,000 last year, but the latter operates at a loss. Costs are rising at both mines. The Progress is practically worked out, but the Blackwater contains 90,000 tons of ore, and has a fair future.

The Kerr Lake Mines Co. of Ontario, Canada, acquired the Rimu gravel property on the Hokitika River, in the South Island, and sent a 10-cu. ft. dredge from New York early in 1921. Of the 1150 acres, 880 acres have been prospected and contain 63,121,000 cu. yd., plus 20,000,000 outside of that area. Of the former, 30,714,000 yd. will average 16.07 cts. per yd., and 32,407,000 yd. 10.04 cts. The boat will dig about 7500 yd. daily.

Canada

The tables below tell the history of mining precious metals in the Dominion. Gold is mounting steadily, and by 1922 should equal the output of 1916. That for 1920 would have been greater only for shortage of power and labor. The Porcupine field passed through a sort of transition period after 1916, when the Dome mine was closed and its plant remodeled, and the Hollinger also made alterations and improvements. Several proposed mergers should soon be consummated, and operations extended. The Kirkland Lake field should report gains from now on. So also should the outlying districts, such as Matachewan and Boston

Creek. The Provincial Department of Mines has recently published some useful bulletins pertaining to these fields. The Cobalt silver field continues to decline, which is only natural considering the character of the deposits. The bright spot is the Nipissing mine.

GOLD

Year.	Value.	Year.	Value.
1890	$1,149,776	1906	$11,502,120
1891	930,614	1907	8,382,780
1892	907,601	1908	9,842,105
1893	976,603	1909	9,382,230
1894	1,128,688	1910	10,205,835
1895	2,083,674	1911	9,781,077
1896	2,754,774	1912	12,648,794
1897	6,027,016	1913	16,598,923
1898	13,775,420	1914	15,983,007
1899	21,261,584	1915	18,977,901
1900	27,908,153	1916	19,234,976
1901	24,128,503	1917	15,272,992
1902	21,336,667	1918	14,463,689
1903	18,843,590	1919	15,580,423
1904	16,462,517	1920	15,853,478
1905	14,159,195		

SILVER

Year.	Ounces.	Cents per Ounce.
1904	3,577,526	57.22
1905	6,000,023	60.35
1906	8,473,379	66.79
1907	12,779,799	65.33
1908	22,106,233	52.86
1909	27,529,473	51.50
1910	32,869,264	53.49
1911	32,559,044	53.30
1912	31,955,560	60.83
1913	31,845,803	59.79
1914	28,449,821	54.81
1915	26,625,960	49.68
1916	25,459,741	65.66
1917	22,221,274	81.42
1918	21,383,979	96.84
1919	16,020,657	111.12
1920	12,793,541	100.90

In the Preliminary Report of the Dominion Department of Mines for 1920, John McLeish made the following summary:

Gold.—The total production of gold in 1920 amounted to 766,912 oz. valued at $15,853,478, against 766,764 oz. valued at $15,580,423 in 1919. Of the total production, 84,659 oz., or 11 per cent., was produced from placer or alluvial mining; 582,852 oz., or 76 per cent., was in the form of bullion; 44,982 oz., or 5.9 per cent., was in blister copper and lead bullion; and 54,399 oz., or 7.1 per cent., in residues and ores exported.

Production in Nova Scotia was only 690 oz., against 850 oz. in 1919. This province has fallen off rapidly during the last few years. Quebec yielded 955 oz., against 1470 oz. This, as usual, is derived from the pyritic ores of the Eastern Townships and the zinc-lead ores of Notre Dame des Anges, Portneuf County. Production in Ontario amounted to 564,959 oz., compared with 505,739 oz., being an increase of 11.7% and by far the greatest production ever recorded. Ontario in 1920 produced 73.7% of the total production of Canada, against 65.9% in 1919. Manitoba gave 781 oz., against 724 oz. in 1919. This was derived, as in the past few years, from the gold and copper ores of The Pas district, northern Manitoba. Production from British Columbia amounted to 127,387 oz. against 167,252 oz. in 1919, being a decrease of 23.8%. Pro-

duction for the last few years has been much below the normal of from 220,000 to 298,000 oz. per year. Production from the Yukon Territory was 72,140 oz., against 90,705 oz. in 1919. This is derived almost wholly from the alluvial gravels, with also a small quantity from the gold ores of the Conrad district.

Exports of mine gold bullion, gold-bearing dust, nuggets, gold in ore, etc., are recorded for 1920 as $4,642,909, against $5,037,123 in 1919, $10,040,813 in 1918, and $15,929,051 in 1917. The apparent decrease is largely due to the prohibition of exports of gold and the purchase by the Ottawa Mint of most of the bullion formerly exported. The final disposal of the coining bullion is not included as a commercial export.

Silver.—The total production of silver in 1920 amounted to 12,793,541 oz., valued at $12,908,683, or an average of 100.9 cts. per oz., against 16,020,657 oz., valued at $17,802,474, or an average of 111.122 cts. per oz. in 1919, a decrease of 20.8 per cent. in quantity and 27.5 per cent. in value. Of the total production, 8,797,781 oz., or 68.7 per cent., was produced as bullion and refined silver; 2,291,585 oz. or 17.9 per cent., as contained in blister copper and lead bullion; and 1,704,175 oz., or 13.4 per cent., estimated as recovered from ores exported.

Production in Quebec amounted to 60,874 oz., against 140,926 oz. in 1919. It was derived as usual from the pyritic ores of the Eastern Townships and the zinc-lead ores of Notre Dame des Anges, Portneuf County. Ontario yielded 9,542,466 oz., against 12,117,878 oz. in 1919, and was derived as in past years mostly from the silver-cobalt-nickel ores of Cobalt and adjacent districts. Of the total Ontario production, 5,308,852 oz., or 55.6 per cent., was recovered in the mills and reduction works of Cobalt; 3,335,076 oz. or 35 per cent. was recovered in the southern Ontario smelters; 136,874 oz. or 1.4 per cent. was the production from the gold mines and the Port Colborne refinery, and 761,664 oz., or 8 per cent., was the estimated recovery from ores, residues, etc., exported to United States. Production in Manitoba was 15,330 oz. against 20,760 oz. in 1919, and was derived from the gold and copper ores of The Pas district, northern Manitoba. British Columbia produced 3,158,707 oz., compared with 3,713,537 oz. in 1919. This production includes 1,131,116 oz., or 35.8% of silver in lead bullion; 1,145,165 oz., or 36.5% contained in blister copper; 881,637 oz. or 27.9% the estimated recoveries from ores exported. Production from the Yukon, Territory was 16,164 oz., against 27,556 oz. in 1919. This was derived mostly from placers, with also a small recovery from the gold and copper ores.

Exports in 1920 were: silver in ore, concentrate, etc., 1,903,130 oz., valued at $2,007,550, and silver in bullion 9,931,374 oz. valued at $10,230,659, against silver in ore, concentrate , etc., 4,225,007 oz. valued at $3,735,830, and silver in bullion 15,132,069 oz. valued at $14,647,072 in 1919.

Imports were: silver sterling, etc., valued at $314,869 and silver bullion valued at $2,453,450, against silver sterling valued at $131,766 and silver bullion valued at $3,458,097 in 1919.

British Columbia.—To the end of 1920, this Province has produced gold valued at $188,697,000, and 86,617,000 oz. of silver. Placer gold was first recorded in 1858, and amounts to $75,944,000. In 1920, the yield of this gold was $221,600. There has been a steady decline since the $1,115,000 in 1904. The year of greatest productivity was $3,913,000 in 1863. Gold from lode mines was first recorded in 1893, when the value was $23,400. From then until 1913, when the total was $5,627,000, there was more or less of a regular, though large, annual increase.

Save for the year 1917, the output for 1920 was the lowest since 1898. While lode gold is affected by the state of base-metal mining, it is not nearly so much as silver, because there are mines producing straight gold ores, such as the Nickel Plate and some in the Rossland district. Silver, on the other hand, has a tendency to maintain its level. Until recently, when the Premier and Dolly Varden mines started to ship ore, this metal was a by-product of base-metal mines. The table of silver outputs by years, placed against the lead and copper yields, shows that from 1903 to 1911, inclusive, when lead and copper averaged 40,000,000 lb. each per annum, silver averaged 2,800,000 oz.; while from 1912 to 1920, inclusive, when lead averaged 43,000,000 lb. and copper 52,000,000 lb. per year, silver increased to 3,300,000 oz. During the latter period, zinc ores yielded 29,000,000 lb. per year—that for 1919 being 56,737,000 lb.—but this ore did not affect the total much. These deductions are from the figures of the provincial mineralogist, W. F. Robertson. The following table gives recent production figures:

Year.	Gold.		Silver, Ounces.
	Lode Mines.	Placers.	
1912	$5,322,442	$555,500	3,132,108
1913	5,627,490	510,000	3,465,856
1914	5,109,004	505,000	3,602,180
1915	5,167,934	770,000	3,366,506
1916	4,587,334	580,500	3,301,923
1917	2,367,190	496,000	2,929,216
1918	3,403,812	320,000	3,498,172
1919	3,150,645	286,500	3,403,119
1920	2,481,392	221,600	3,377,849

While lode gold has fallen off over 50 per cent. since 1915, and placer gold 70 per cent., silver is practically the same as in that year, indicating a fairly strong condition.

If engineers are not mistaken, the silver output of the Province will be considerably swelled in the near future by the metal extracted from the Premier and Dolly Varden mines. It is hoped that some of the adjacent properties will becomes producers also.

Geology of the Portland Canal district was briefly discussed by V. W. Wilhelm, who said[1] that subsequent to the primary mineralization, the entire district was intruded by small irregular dioritic dikes, which cut but do not interfere with the continuity of the mineralized shear-zones. The metallic sulphides are disseminated through the altered quartz-porphyry, as well as the quartz veins. An average sample from the Missouri mine gave 0.03 oz. gold, 2.3 oz. silver, 2.5 per cent. lead, 5.2

[1] *Min. Sci. Press*, **122**, 95 (1921).

zinc, 0.6 copper, 14 iron, and 59 per cent. insoluble. Mr. Wilhelm considers that provided a considerable tonnage is developed, the district offers no great difficulties to successful mining operations. The area is 12 to 20 miles from tide-water, and railroad construction would not be difficult. The rich ores can be smelted, but the low-grade ores will require considerable experimentation before a successful treatment process is evolved.

Extensive development and production continued at the Premier and Dolly Varden mines. The former yielded 92,183 oz. of silver and 2700 oz. of gold from 850 tons of ore; the latter, really in the Alice Arm district, yielded 1,170,000 oz. of silver during the period Sept. 1, 1919, to Sept. 30, 1920, and 870,000 oz. during the full year 1920, from 28,000 tons of ore.

In discussing the geology of the Salmon River district, Portland Canal, before the Canadian Institute of Metallurgy and Mining, Dr. Schofield, of the University of British Columbia and formerly of the Canadian Geological Survey, stated that the most important rocks were the quartz-porphyries and the tuffs, and observed that most orebodies occurred at the contact. The only instances of secondary enrichment in the district were the discovery of native silver along fault-line in orebodies, but these deposits did not go to any depth. The ordinary silver orebodies, however, were likely to be found to continue at depth, so that some of the properties under development might be expected to prove valuable mines.

The history of the Dolly Varden mine was told in a readable manner by A. J. T. Taylor,[1] who said that discovery was made in 1914 by a prospector, Ole Evindsen. The property now includes eight claims. The financial troubles arising from the 17-mile railway were fully discussed. Ore reserves by the middle of 1919 were 40,000 tons, averaging 36 oz. of silver per ton. In the Wolf claim were 120,000 tons of 15-oz. ore.

Since the Dolly Varden mine has proved to be such a potential silver producer, Robert Dunn states[2] that prospecting in the Alice Arm region has been much stimulated. Completion of the Taylor Mining Co.'s 18-mile railway is a great aid. Owing to the topographical difficulties encountered, and the short season, exploration is necessarily somewhat slow.

The Belmont-Surf Inlet company was the most important gold producer as usual. Its yield last year was 50,000 oz. of gold and 30,000 oz. of silver, with some copper, from 100,000 tons of ore. Regular dividends were paid.

[1] *Min. Sci. Press*, **120**, 631 (1920).

[2] *Eng. Min. Jour.*, **109**, 643 (1920).

Manitoba.—More interest is being taken in the possibilities of this Province, according to J. S. De Lury.[1] The Rice Lake and Herb Lake districts are the most important gold regions. At the former were several discoveries, and at the Gold Pan, Gold Seal, and Gold Pan Extension, exploration was continued to depths of 200 to 250 ft.

Ontario.—Value of the gold and silver production in this Province showed a decline of over $2,000,000 compared with that of 1919. While gold is greater than ever, silver falls off each year. According to J. A. McRae,[2] ore reserves are valued at $70,000,000, this alone insuring a bright future for at least seven years. Milling facilities aggregate nearly 7000 tons a day, while at the end of 1920 only 60 per cent. of these plants were in operation. The Porcupine district accounts for 6120 tons, and Kirkland Lake 650 tons, so the possibilities of increasing the tonnage are considerable. One of the most promising gold-mining regions in the world lies in northern Ontario, including the two fields mentioned.

PRODUCTION OF GOLD AND SILVER IN ONTARIO

Year.	Province. Gold, Oz.	Porcupine. Gold, Oz.	Province. Silver, Oz. (a)	Cobalt. Silver, Oz. (b)
1906	3,202	.....	5,401,766	5,401,766
1907	3,212	.....	9,982,363	10,023,311
1908	3,212	.....	19,398,545	19,437,875
1909	1,569	.....	24,822,099	25,897,825
1910	3,089	1,947	30,366,366	30,645,181
1911	2,062	755	30,540,754	31,507,791
1912	85,523	83,725	29,214,025	30,243,859
1913	219,801	207,748	28,411,261	29,681,975
1914	268,264	251,131	25,139,214	25,162,841
1915	406,577	366,574	22,748,609	24,746,534
1916	492,481	452,095	21,608,158	19,915,090
1917	431,355	410,000	19,479,691	19,401,893
1918	411,879	375,806	17,409,263	17,661,694
1919	505,963	481,319	11,363,252	11,214,317
1920	564,309	512,625	10,968,358	10,831,146

(a) Dominion Department of Mines figures. (b) Ontario Bureau of Mines figures. The excess of the Cobalt output over that of the whole Province in some years is probably due to different methods of reporting shipments.

Dividends paid in 1920 were $3,240,042 by gold and $4,058,143 by silver companies, making the totals $18,785,280 and $82,575,041, respectively.

According to W. R. Rogers, statistician of the Ontario Department of Mines,[3] the gold output of 1920 exceeded that of silver in value for the first time since 1903. This speaks well for the industry, which has gone ahead despite the abnormal period of 1914–1920. The Hollinger now has reserves valued at $40,000,000, and at Kirkland Lake the Lake Shore mine shows persistence of ore to a depth of 925 ft.

In addition to the $11,665,000 gold produced in Ontario in 1920, the

[1] *Bull. Can. Min. Inst.*, Jan., 1921.
[2] *Can. Min. Jour.*, Jan. 7, 1921.
[3] *Can. Min. Jour.*, Jan. 7, 1921.

companies will receive a premium of 10 to 18 per cent. on account of the exchange between Canada and New York.

The Porcupine field was described by J. Mackintosh Bell at a lecture delivered by him at Harvard University during 1920. It is the youngest of the world's great gold fields, and in spite of many vicissitudes has emerged with vigor for a great future. A prospector named J. S. Wilson is responsible for discovering gold there in 1909. There are many types of ore deposits, the most characteristic being a quartz lens of irregular shape, without much definition either in vertical or horizontal dimensions. Ordinarily there are a series of lenses connected, sometimes slightly overlapping or parallel, separated by schist. This interesting lecture also discussed the general geology and outputs of the mines. In 1920, the tonnage was 1,162,065, yielding an average of $9.20 per ton, equal to a total of $10,690,562.

The workable orebodies of the Cobalt district are all in the diabase and the conglomerate (Keewatin) which it intrudes. None of the 200 veins has carried pay-ore out of this formation, according to A. R. Whitman,[1] who believes that the cobalt-nickel-silver ore emanated from the diabase itself, rather from its mother magma. A companion paper[2] was that by W. L. Whitehead, who concludes that it is unreasonable to attempt to connect the origin of the veins with hydrothermal activity from the diabase itself. The metals may, however, have been derived from the cool diabase by leaching.

Quebec and Nova Scotia.—T. C. Denis, in charge of the Mines Department of Quebec, said[3] that prospecting for gold was inactive in that Province during 1920. Other callings were more attractive. Some work was done near the headwaters of the Harricana River.

There is nothing of note to report for Nova Scotia, which produces a few hundred ounces of gold.

Yukon.—Although the decline in gold output continues, this territory will enter the ranks as a silver producer, due to the discovery on Keno Hill, 40 miles by wagon-road from Mayo on the Stewart River, between the head of Lightning Creek, a tributary of Duncan Creek, and Christal Creek, in central Yukon. Work was originally done in 1919, but late in 1919 rich silver-lead ore was uncovered, and the Yukon Gold Co., the largest gold producer in the region, acquired the six principal claims in 1920. Over 800 claims had been staked by November, 1920. This discovery is considered to be the most important since gold was found near Dawson in 1896. The rocks exposed are gneissoid quartzites, quartz-mica schists, and mica schists. They are cut by a dike of greenstone,

[1] *Econ. Geol.*, **15**, 136 (1920).
[2] *Econ. Geol.*, **15**, 103 (1920).
[3] *Bull. Can. Min. Inst.*, Jan., 1921.

considerably sheared and eroded. To November, 1920, $150,000 had been spent, and to July, 1921, a further $700,000 would be expended. Reserves to October were 5000 tons, assaying 200 oz. of silver per ton, and 68 per cent. lead.

GOLD PRODUCTION IN KLONDIKE

Year.	Ounces.	Year.	Ounces.	Year.	Ounces.	Year.	Ounces.
1896....	14,513	1903.....	592,594	1910.....	221,091	1917.....	177,600
1897....	120,937	1904.....	507,938	1911.....	224,197	1918.....	102,474
1898....	483,750	1905.....	381,001	1912.....	268,447	1919.....	90,705
1899....	774,000	1906.....	270,900	1913.....	282,838	1920.....	72,140
1900....	1,077,553	1907.....	152,381	1914.....	247,940		
1901....	870,750	1908.....	174,150	1915.....	230,173		
1902....	701,437	1909.....	191,565	1916.....	212,700		

The Yukon Gold Co. now has only three dredges at work near Dawson, against nine in 1913. The amount of gravel hydraulicked is practically maintained. The Canadian Klondyke company is being reorganized, but operates three boats.

MEXICO

It was stated in the introduction to this chapter that to aid the mines of this country the export tax has been taken off silver when that metal is quoted at under 60 cts. (U. S.) per oz. This was a wise move, as about 1200 silver and copper mines, a third of the total, were closed through low prices. The States affected most are Chihuahua, Coahuila, Durango, Guanajuato, Hidalgo, and Zacatecas. Mexican mining has been gradually improving under more stable Government, and it is a pity that when there is an opportunity to operate, markets are against the producers.

The following tables show the output of precious metals in a period of 30 years:

Year.	Gold, Value.	Silver, Oz.	Year.	Gold, Value.	Silver, Oz.
1891.....	$1,275,000	35,200,000	1906.....	$18,534,700	54,400,000
1892.....	1,400,000	39,600,000	1907.....	18,681,100	68,200,000
1893.....	1,305,000	44,100,000	1908.....	22,371,200	72,250,000
1894.....	1,463,000	46,800,000	1909.....	23,842,900	72,320,000
1895.....	5,100,000	50,890,000	1910.....	24,910,600	78,000,000
1896.....	6,310,000	41,374,000	1911.....	24,880,100	80,650,000
1897.....	7,121,000	40,800,000	1912.....	24,500,000	74,640,000
1898.....	8,236,000	42,400,000	1913.....	19,308,800	70,703,000
1899.....	9,277,000	41,700,000	1914.....	4,788,175	70,703,000
1900.....	9,409,000	43,450,000	1915.....	6,559,275	39,570,000
1901.....	10,329,316	46,910,000	1916.....	7,690,100	22,838,000
1902.....	11,293,524	49,100,000	1917.....	9,000,000	35,000,000
1903.....	10,677,500	57,400,000	1918.....	16,824,700	62,517,000
1904.....	12,605,300	49,200,000	1919.....	15,248,000	62,682,000
1905.....	16,107,100	60,000,000	1920.....	15,500,000	64,000,000

Two of the bright spots in Mexico are the El Oro and Pachuca districts. In the former are such important producers as Dos Estrellas, El Oro,

Esperanza, and Mexico Mines of El Oro. The monthly tonnage aggregates 80,000 tons. At Pachuca, Santa Gertrudis operates at full capacity, and is deriving good results from its El Bordo mine; while the Real del Monte mines of the U. S. Smelting, Refining & Mining Co. continue to be the largest silver producers in the world.

"A Backward and a Forward Look at the Mining Industry in Mexico" was the title of a brief review of that country by Kirby Thomas.[1] He said:

> Aliens, and alien capital have, since the days of the prolonged revolution, which made Mexico a politically independent country, played an important part in the development of Mexico's great mineral resources; and during the successive periods of activity and prosperity in the industry, have been preponderant both as to financial interest and as regards the practical and technical operations of the country's varied and vast mining developments. As early as 1824, English capital engaged in large and widely distributed mining operations in Mexico. During this early period minor operations were carried on by German and French companies also. The records do not show any American operations, a fact to be expected on account of the complete absorption of American energies in the development of domestic resources during that time. By the middle of the last century, practically all of these foreign companies, which had made such a vigorous and effective beginning in the development and realization of Mexico's great mineral resources, had withdrawn from the country. The reason for this decline in an essential and especially favored industry was chiefly due to the bad internal conditions which continued to grow worse in Mexico from a very bad start at the beginning, and to difficulties growing out of the failure of the local Mexican governments to protect life and to insure the integrity of property. Previous to the constitution of 1857, no foreigner in Mexico could own real estate or mines, and consequently these foreign companies, operating under leases and through local companies, were constantly harassed and perpetually in danger in the courts and through the various decrees and laws.
>
> Mining was indeed at a low ebb at the beginning of the Diaz regime in Mexico in 1876. The inauguration of the stable government and liberal foreign policies by Diaz and the construction of government-promoted railroads was the occasion and incentive for a new era in Mexican mining. Beginning about 1876, American capital was first attracted to mining in Mexico, at the outset naturally on the states nearest the border, and soon throughout the whole country, anticipating or following projection of the trunk-line railroads. By 1907, $250,000,000 had been invested in mines and smelters by Americans, against $15,000,000 by Mexicans. By 1910, Americans and British controlled 90 per cent. of the operating properties.

Progress in Mexico was the subject of a letter by W. F. Saunders, secretary of the American Chamber of Commerce in Mexico, in January, 1921. He called attention to the possibilities of the southern neighbor, and was anxious that the trade conference to be held in Mexico City in April, 1921, should be well attended. It is estimated that there are 14,000 Americans in Mexico.

[1] *Ariz. Min. Jour.*, 4, 13 (1921).

Opportunities for mining on the West Coast of Mexico were briefly covered in the *Arizona Mining Journal* of Feb. 1, 1921. There are old and long-abandoned mines worth exploration, and many good possibilities in the State of Sonora.

The Governors of the states of Durango and Zacatecas were interviewed[1] during the year, and intimated that they would aid mining as much as was in their power.

Some of the other papers that were published during the year were as follows: "Prospects in Mexico,"[2] a political review; "Conditions in

FIG. 4.

Mexico,"[3] also political; "The Mexicans, Who and What They Are,"[4] historical and social; and "Metal Prices and Mining in Mexico,"[5] by H. G. Nichols, calculations of prices and making of a desirable furnace mixture.

A review of the ore deposits of Mexico sounds like a big order, but they were briefly though fully discussed by S. J. Lewis in a series of six articles in the *Mining and Scientific Press*.[6] They came under the sub-heads of (1) "General;" (2) "Ore Deposits in Sedimentary Rocks. The Barreno

[1] *Min. Sci. Press*, **120**, 667 (1920).
[2] *Min. Sci. Press*, **120**, 855 (1920).
[3] *Min. Sci. Press*, **121**, 345 (1920).
[4] *Min. Sci. Press*, **121**, 443 (1920).
[5] *Min. Sci. Press*, **121**, 655 (1920).
[6] **120**, 412, 443, 933; and **121**, 16, 375, 521 (1920).

and Ajuchitlan Mines;" (3) Non-contact Deposits in Sedimentary Rocks;" (4) "Ore Deposits in Limestone and Not of Direct Igneous Origin;" (5) "Ore Deposits in Igneous Rocks;" and (6) "Ore Deposits in Surficial Flows of Igneous Rock." In the third paper Mr. Lewis instances El Oro, where rich veins of gold-silver ore have been followed through shale into andesite and again into shale. The ore does not follow the contacts between the shale and intruding andesite. In the sixth paper are mentioned such well-known mines as Amparo, Cinco Minas, and

Gneisses and Schists.
Post-Cambrian Intrusives
Lower Cretaceous
Upper Cretaceous
Tertiary Effusives.
Earlier Tertiary
Later Tertiary
Quaternary
GULF OF MEXICO
Geologic Map of MEXICO.
Reduced and generalized from Hills & Stose, "Stratigraphy of North America," Prof. Paper 71, U.S. Geol. Survey. Undetermined areas left blank.
Scale: 1 to 10000,000.

FIG. 5.

Esperanza. The papers are of considerable value to geologists, prospectors and operators.

The Tigre mine of the Lucky Tiger Combination Gold Mining Co. of Missouri has produced over 700,000 tons of ore assaying 0.25 oz. of gold, 39 oz. of silver, 0.25 per cent. copper, 1.0 lead and 1.5 per cent. zinc, since 1903. Good dividends have been paid annually. Three products are shipped to smelters in Arizona—ore, concentrates, and bullion, according to R. T. Mishler,[1] who discussed the geology of El Tigre district of Sonora. In the Tigre mine are four workable veins. They

[1] *Min. Sci. Press*, **121**, 583 (1920).

have been deposited along fissures. The filling is composed of kaolinized or partly silicified country rock, usually with deposition along the fissure planes and in the interstices between the fragments of country rock. Ore consists of mixed sulphides of zinc, iron, lead, copper, and silver, in a gangue of quartz and silicified rhyolite. Gold is associated with the copper. The wall-rock is rhyolite and rhyolite-tuff. Careful study of geologic conditions has been of much benefit during development. In this district are the North Tigre and Santa Maria mines, two miles north of El Tigre, and the Cinco de Mayo and Roy mines, two miles farther on.

In discussing ore-buying in Mexico, C. A. Grabill says[1] that generally methods vary little from those in the United States. This is naturally so, as five of the principal smelters are operated by the American Smelting & Refining Co. and five by a subsidiary of the American Metal Co., while prices for copper, lead, and silver are based on New York quotations. At one time there were a number of ore-buying agencies scattered through the principal mining regions, but competition became keen and only the big fellows survived. There were a number of small smelters along the Sierra Madres, but these are abandoned, dismantled, or idle.

Central and South America

The combined gold output of Central and South America was $7,000,000 in 1890, $12,200,000 in 1896, and from 1904 onward the annual yields were:

1904	$11,581,000	1913	$14,370,000
1905	12,224,000	1914	15,002,000
1906	12,599,000	1915	17,274,000
1907	13,913,000	1916	18,706,000
1908	14,337,000	1917	17,757,000
1909	13,864,000	1918	16,200,000
1910	15,969,000	1919	17,400,000
1911	15,862,000	1920	18,500,000
1912	15,806,000		

Honduras.—Production during 1920 is not likely to be much different from the 10,400 oz. of gold and 1,836,000 oz. of silver reported in 1919.

A brief review[2] of the New York & Honduras Rosario Co.'s mines showed that they have yielded nearly 1,000,000 tons of silver-gold ore since 1912. The ratio of silver to gold is 155 to 1. In 1919 the yield was 1,584,579 oz. and 10,200 oz., respectively. The silver exists mainly as stephanite. There are over 60 miles of underground workings. The ore is treated by cyanidation. Extraction is high; costs are reasonable; power is cheap; and labor is plentiful.

Nicaragua.—This Republic has an area of 49,200 sq. miles and a population of 690,000, according to Louis Garbrecht,[3] who gave new

[1] *Eng. Min. Jour.*, **109**, 694 (1920).
[2] *Eng. Min. Jour.*, **110**, 1163 (1920).
[3] *Eng. Min. Jour.*, **109**, 791 (1920).

details of the mining fields of the eastern part. This region is generally inaccessible, and suffers from a lack of transportation facilities. From a prospector's point of view it is practically virgin territory, and apart from gold deposits its mineral resources are unknown. It costs up to $140 per ton to carry supplies from New Orleans to the Pis Pis district. Mining laws are good. The only tax is an export duty on gold. Quartz veins lie chiefly in the volcanic flows—andesite and gabbros. The Pis Pis district is the most important source of gold. The region is rugged. It has produced about $12,000,000 during the past 30 years. There are two types of veins: one system consists of the filling of primary fissures, and is only slightly mineralized. The gold content is from $3 to $8 per ton. Only the oxide ores have been mined, due to the cost of treating the somewhat refractory ores below. The second system of veins consists of filling of secondary fissures. They carry more gold ($12 per ton) and mineral than the first, but are of less extent. The largest mines in this district are the Bonanza, Concordia, Constancia, Eden, Leticia, Lone Star, and Siempre Viva. The third and fourth mentioned are the only ones that operated on any scale, with modern equipment. In the Bana Cruz district is the America mine, which has 40,000 tons of $12 ore.

In a district 15 miles south of Pis Pis is La Luz & Los Angeles, a steady producer during the past 23 years. It has been difficult to secure any information concerning this profitable venture, but a full account of its activities was given by Jesse Scobey.[1] There was no outcrop or quartz vein when first worked in 1897, simply gold-bearing dirt on a hillside. By the end of 1898, one Huntington mill had saved $38,400 from 4800 tons. In 1905 three such machines were crushing $10 ore. When examined in that year, the deposit was estimated to be 750 ft. long by 400 ft. wide and 100 ft. deep. From 1901 to 1920 the yield was 540,145 tons of $8.15 ore, valued at $4,399,334. No work was carried on below a depth of 60 ft. during this period. The treatment of the ore will be described under the metallurgical section of this chapter.

Nicaragua reported an output of 75,700 oz. of gold and 317,800 oz. of silver during 1919, which would probably be exceeded in 1920.

Salvador.—There is little news available from this country, which produced 27,300 oz. of gold and 613,000 oz. of silver during 1919. Most interest is directed to operations of El Salvador company, a consolidation during 1919.

Boliva.—This is a silver-producing country. J. T. Singewald, Jr., who has written considerably on South America, made another contribution in his paper "Revival of the Colquechaca Silver-Tin District in

[1] *Eng. Min. Jour.*, **110**, 6 (1920).

Bolivia."[1] The ancient mines of the Andes that yielded high-grade silver-tin ore from narrow fissure-veins in igneous rocks are being reworked. Present operators contemplate using flotation to recover both metals. The largest operator is Simon I. Patiño.

Mr. Singewald also discussed[2] ore deposition in the Bolivian tin-silver deposits, following a 34-page article on that subject by W. M. Davy.[3] Both have examined the region. In the past Bolivia has produced an enormous quantity of silver; its present annual output is about 1,500,000 oz. There are three classes of veins, and one is that in which there is little or no tin; but they have not been worked for a considerable time, prior to activity in tin mining.

According to G. W. Schneider and B. L. Miller,[4] silver, tin, bismuth, and tungsten ores are in close association in Bolivia. They state that it is difficult to separate the districts on the basis of metalliferous ores. This is especially true in regard to silver and tin, which are often found in the same veins, or in different veins in the same region. In the Potosi district, six companies are operating. The Cerro Rico de Potosi is honeycombed with old workings from summit to base, and is supposed to have yielded over one billion ounces of silver. The present mines produce up to 500 tons of tin concentrates per month, containing considerable silver. The Oploco mine in the Chocaya district also produces silver with its tin. Concerning gold, the Incaoro mines at Pallaya, and the Olla de Oro east of La Paz (the capital), are the only lode mines of importance. Natives wash gravel on the northeast of Lake Titicaca, while on the Tipuani River an American company is preparing ditches for hydraulicking.

Brazil.—The only producers of note are the Morro Velho and Passagem (Ouro Preto Co.) mines, which operated regularly during 1920.

The Morro Velho mine of the St. John del Rey Co. is now 6426 ft. deep vertically. The rock temperature at that depth is 118° F., compared with 65° at the surface.[5] The orebody has become longer and narrower in depth, being 1000 ft. long and 12 to 15 ft. wide on the lower levels, compared with a nearly uniform length of 600 ft. and width of 45 ft. in the upper workings. New shafts are to be sunk to supersede the series of internal shafts, each 1200 ft. deep. During its last fiscal year the company extracted 105,537 oz. of gold from 166,000 tons of ore. To the end of 1919 the total was £13,350,000 from 6,940,000 tons.

British Guiana.—According to the Department of Lands and Mines for British Guiana, the gold production of the colony covering a period

[1] *Eng. Min. Jour.*, **110**, 763 (1920).
[2] *Econ. Geol.*, **16**, 60 (1921).
[3] *Econ. Geol.*, **15**, 463 (1920).
[4] *Eng. Min. Jour.*, **109**, 787 (1920).
[5] *Min. Sci. Press*, **121**, 477 (1920).

of 30 years has been over $50,000,000, practically all from river and stream placers. The great interior highland of British Guiana is comprised almost entirely of granite and metamorphic rocks, and the streams in this formation are nearly all gold bearing. On the Cayuni River the gold is exceptionally coarse and of great purity. Many nuggets of several hundred ounces have been produced. The gravel is shallow, from a few inches to 6 ft. in depth, and easily washed by simple methods. Pay-gravel is generally narrow, though sometimes up to 200 ft. wide. The Cayuni River has many rapids and is of little value for transportation of supplies or materials. One of the main tributaries of the Cayuni River, the Yuruon, receives the waters of the Yuru River, which flows from the Venezuela highlands, in which is the well-known Callao gold mine. This property, under an American-British company, yielded upward of $20,000,000 in gold. These streams also drain the new placer-gold district in Venezuela. The gold exports in 1920 amount to 8883 oz.

Chile.—Up to the 18th century Chile held third place among gold-producing countries; but in 1920 it was nearly the lowest on the list, according to Lawrence Pitblado.[1] Chile is a great copper country; its mining laws are favorable and there are no labor conditions involved. This last factor militates against operation of likely gold mines by foreign companies, as owners demand such high prices. There are low-grade orebodies around Tiltil, to the north of Santiago; also 50 miles south of that city, between Rancagua and Melipilla; but they are being simply held. On the headwaters of Alhué Creek, at an elevation of 3000 ft., the Albion Mining Co., Ltd., is operating the Mines de Oro de Alhué. The main lode was mined as early as 1700. The vein is of quartz and rhodonite, in diorite and schist. In this region climatic conditions are ideal, as are the economic features.

Colombia.—While dredging for gold and platinum holds most interest, lode mining is attracting considerable attention. The gold yield during 1919 was approximately 300,000 oz., which should be increased in 1920.

Dutch Guiana.—Gold production declines steadily in this colony. There has been nothing of importance to chronicle. The output in 1919 was about 16,000 oz., of which 40 per cent. was from one company. The Guiana Development Co. has erected a 7-cu. ft. dredge, constructed by the Yuba Mfg. Co. of California.

Peru.—Official figures for 1919 were 57,600 oz. of gold and 9,781,000 oz. of silver. Probably those for 1920 will be somewhat similar.

Cerro de Pasco is a large silver producer, of course as a by-product of copper, and save Real del Monte in Mexico, is the greatest in North and

[1] *Mining Mag.*, Jan., 1921.

South America. During the five years 1916–1920, the average was 5,200,000 oz. per annum. The total from 1907 to the end of 1920 was 45,904,700 oz. of silver, also 292,825 oz. of gold, according to a report issued by the company late in 1920.

In his "Across the Peruvian Andes by Mule Back,"[1] J. T. Singewald, Jr., describes briefly the Quespesisa mines, 10 kilometers from Santa Ines and 130 kilometers from the port of Pisco. This district, overlooking Lake Orcoccocho, at an elevation of 16,500 ft., has been one of the most productive silver regions in Peru. The surroundings are bleak, desolate, and cold. Ores, which average 50 oz. of silver per ton, are in veins traversing igneous rocks. Crude treatment has extracted 6,000,000 oz. during the last 50 years. Recovery is only 75 per cent.

Venezuela.—Interest has been revived in a new gold-placer region in the southeastern part of this country, which was first made public in 1915, according to Kirby Thomas.[2] The area is about 250 miles directly south of the Orinoco delta on the border of British Guiana, and extends into that country, where the district is as yet entirely virgin. It is claimed that General Fernandez, one of the discoverers of the new district, took out over $300,000 of gold in three months, and other sensational strikes were reported. The district is remote from main lines of travel. The itinerary advised is from Trinidad up the Orinoco to San Felix, and from there a three and one-half day mule-back trip to Callao, from which point a two-day mule trip takes one to the Cayuni River. Here canoes are secured, and if lucky the remaining 50 miles to the objective is covered in one week.

The climate is reported to be bad. Mosquitoes are said to work all night.

Europe

No data of value are available from the Continent, nor is there likely to be until affairs are normal. The total value of precious metals, excluding Russia, is only about $15,000,000 per annum, not an important factor.

France.—In his review[3] of the mineral resources of this country and its colonies, Maurice Altmayer makes no reference to gold and silver, from which it may be inferred that there are no deposits worth exploitation. Late in 1920 it was reported that an auriferous vein had been uncovered somewhere near the capital.

Jugo-Slavia.—In discussing the mineral wealth of Jugo-Slavia, Captain G. Gordon-Smith considers[4] that the Kingdom has great possi-

[1] *Bull. Pan Amer. Union*, Feb., 1921.
[2] *Eng. Min. Jour.*, **110**, 1088 (1920).
[3] *Eng. Min. Jour.*, **109**, 812 (1920).
[4] *Eng. Min. Jour.*, **110**, 1705 (1920).

bilities. The deposits have been worked for centuries. Placers contain workable gravel, an average of one franc per cubic meter. Four dredges were at work in 1905, but there is room for more. There are quartz veins in crystalline and granitic rocks, in serpentine and gabbro, and in andesitic rocks, all worth investigation.

Russia.—So little information on mining is available from this country of unrest, and statistics are so unreliable, that gold mining must be dismissed briefly. The gold is mainly from Siberia (Asia), where conditions are far from stable. Progress may be judged from the table below:

Year.	Value.	Year.	Value.
1891	$24,131,000	1906	$19,496,500
1892	20,921,000	1907	26,684,300
1893	21,869,000	1908	28,052,200
1894	20,985,000	1909	32,381,300
1895	18,812,000	1910	35,579,600
1896	31,005,000	1911	32,151,600
1897	21,538,000	1912	22,199,000
1898	24,734,000	1913	24,578,000
1899	23,963,000	1914	26,508,000
1900	23,090,000	1915	28,586,000
1901	25,911,000	1916	22,500,000
1902	24,460,000	1917	18,000,000
1903	24,634,200	1918	12,000,000
1904	24,803,200	1919	8,000,000
1905	22,292,000	1920	8,000,000

The mainstay of Siberian gold production is the Lenskoie property of Lena Goldfields, Ltd. In spite of war, revolution, and a transition stage, its output has been pretty well maintained.

Spain.—This country is a silver producer, the by-product of lead. Most of the several million ounces recovered annually is from the Pennaroya mines.

Metallurgy of Gold and Silver

While there is always considerable experimentation under way, little new of importance was chronicled during 1920. Throughout the world there was dearth of literature on gold and silver treatment. The American Institute of Mining and Metallurgical Engineers publications, for instance, had no articles on the subject. As during the last few years, chemistry and precipitation received greatest attention, and it is under these heads that the most information will be found.

Practically the only reviews of progress during 1920 were those of P. A. Robbins and Henry Hanson[1] and by Alfred James.[2] Both refer in felicitous terms to the work of J. S. MacArthur, who died in March, 1920, and Mr. James also to Hennen Jennings, who passed on last year. MacArthur was the originator of cyanidation, while Jennings was instrumental in advancing its use in Africa.

[1] *Eng. Min. Jour.*, **111**, 198 (1921).
[2] *Eng. Min. Jour.*, **111**, 102 (1921).

According to Messrs. Robbins and Hanson:

Looking back over 30 years of progress in the art of extracting precious metals from their ores, two phases of metallurgical endeavor are discernible. The first phase shows a somewhat stubborn avoidance of the use of the cyanide process, coupled with attempts to improve upon MacArthur's invention. The second phase is marked by a world-wide acceptance of the process as originated by the inventor, the efforts of metallurgists being now directed toward the application of preliminary treatments which will make their ores more amenable to cyanidation, rather than endeavoring to devise processes which avoid cyanidation.

The psychological reason for this change in attitude would seem to be due in some measure to the coming of a younger generation of metallurgists, who, without experience or beliefs in other processes, could accept, without questioning, the cyanide process as being generally the most efficient system of extraction yet developed. Any reluctance upon the part of an older generation to abandon processes to which they had become wedded was a very natural and commendable attitude of caution. MacArthur's carefully designed process has remained unchanged, and only in improved mechanical details and in an ever-widening application of the process to refractory gold and silver ores has progress been made.

A discussion before the Institution of Mining and Metallurgy in London concerning the possible use of haloid cyanides revealed no innovations. The only haloid compound that has been put to commercial use is bromo-cyanogen, which, however, is not a solvent for gold unless in the presence of an alkaline cyanide. The consensus of opinion is that the bromide merely acts as an oxidizing agent, a conclusion which seems to receive strong support from the fact that roasting and aëration have in most cases supplanted the use of bromo-cyanogen.

Although the process is still used in Western Australia, it is to be noted that one of the largest mines (the Golden Horse Shoe) in Kalgoorlie, which had previously used bromo-cyanogen, was compelled during the war to resort to ordinary alkaline cyanide treatment, no supplies of bromine salts being obtainable. This company will not return to the use of bromine, owing to the success of the present treatment.

Cyanide containing 36 per cent. equivalent of the free cyanogen in standard sodium cyanide has been used in some American and Canadian mills as a means of reducing costs. The Tonopah Extension reports satisfactory results after 7 months' exclusive use of the low-grade product. No fouling of solution is noted, and an advantage is claimed in that the low-grade salt possesses a high alkalinity, which assists in neutralizing the acidity of the ore, thus saving lime. Acetylene gas and sometimes ammonia are liberated when dissolving the low-grade cyanide, and hence it is advisable that good ventilation be maintained over the dissolving tank.

The impetus given to the production of low-grade cyanide at Niagara Falls has led to marked improvements in methods of manufacture and increases in the free cyanogen content of the product. The manufacturers of standard sodium and potassium cyanide are no doubt able to meet the competition of lower-grade substitutes, yet competition in not only the precious-metal mills but also in the art of steel-hardening and in the killing of scale on plants and trees may be expected to lead to an adjustment in prices of benefit to all consumers. The low-grade cyanide is now manufactured from cyanamid, which latter has its principal use in the fertilizer industry, being one of the cheapest sources of combined nitrogen known, and thus offering an admirable material for transformation into cyanide.

At the Connemara gold mine in Rhodesia, it is claimed that heating the ore previous to cyaniding has raised the extraction from 68 to 86 per cent. The heating is

referred to as "baking," as distinguished from roasting, the heating not being carried to a point where a roast is obtained. The process is stated to drive off water of crystallization from hydrated oxides of iron, thus making the ore more amenable to cyanidation.

The application of flotation to the recovery of slime concentrates at the Belmont Shawmut mill (California) is noted, and is described elsewhere in this chapter.

The McIntyre-Porcupine mines (Ontario) are reported to have decided upon a flotation method for eliminating graphitic material which occurs in certain orebodies, causing losses of gold by premature precipitation.

Few new plants have been constructed during the year, although several enlargements of existing plants have been reported. Although no marked improvements in milling apparatus have been noted, there is an increasing use of electrically vibrated screens, and a number of innovations in flotation apparatus have made their appearance.

Much earnest research work has been done during the year in the roasting and volatilization of refractory precious-metal ores, but experimenters have yet to report satisfactory commercial results.

In the Cobalt district of Ontario, flotation continues to aid in the recovery of silver, as discussed elsewhere in this chapter.

It is rumored that Alaska Juneau has made good progress in improving the company's milling practice by rejecting a considerable portion of the low-grade rock sent to the mill.

There has been some discussion upon, and some experimental work has been carried on with, the electrical precipitation of cyanide solutions, but no improvements of commercial value seem to have developed. From Canada and Mexico reports have come of the continued success and economy of the Crowe vacuum zinc-dust precipitation process, and a number of new installations have been made. Mr. James' review appears in part under *Precipitation.*

Chemistry

An instructive paper on Canadian cyanide, its manufacture and utilization, was presented by W. S. Landis at the annual meeting of the Canadian Mining Institute at Toronto in March, 1920. He mostly covered the operations of the American Cyanamid Co. at Niagara Falls. Although it has been long known that calcium cyanamid could be transformed into cyanide, no commercial process had been developed in the 15 years intervening since that fact was discovered. Production on a large scale was started early in 1917. The product is known as the "Aero" brand. Cyanamid contains calcium cyanamid, $CaCN_2$; calcium oxide (lime), CaO; and graphite, C, with other impurities. Its chief use has been as a fertilizer. The process consists of mixing cyanamid and common salt, and melting it in a peculiar type of single-phase electric furnace. Operating is continuous and largely mechanical. Power consumption is moderate. Temperatures are not high; while wear and tear is not excessive. The finished salt is packed in tight caustic-soda drums holding 375 lb., and so shipped. The product contains 36 to 46

per cent. equivalent sodium-cyanide content, and a 50-per cent. product is aimed at. It dissolves readily, but must be agitated. A little acetylene gas is evolved during dissolving, and as it precipitates gold and silver, the cyanide should not be added to pregnant solutions. The American and Canadian consumption of all cyanides approximates 15,000 tons per annum.

John G. Kirchen[1] compared high- and low-grade cyanides at the Tonopah Extension mill, and found that the results of one month's use of each of the salts were as follows:

Cyanide Content, Per Cent.	Assay of Ore, Oz. Silver per Ton.	Assay of Tailing, Oz. per Ton.	Extraction, Per Cent.	Consumption of Cyanide, Lb. per Ton.	Consumption of Cyanide, Lb. per Oz. of Bullion.
97	11.63	0.90	92.26	1.64	0.142
37	11.34	0.82	92.77	1.71	0.160

In the treatment of 8000 tons per month, there is little difference, yet the higher-grade salt had rather the advantage.

Later[2] Mr. Kirchen confirmed the above results from an operating period of 31 months using 97-per cent. cyanide, treating 276,509 tons of ore, and one of 31 months using 36.3-per cent. cyanide, treating 74,433 tons. This large test showed approximately the same extraction with the high- as well as the low-grade salt. Summarizing he said that their experience indicated that the value of the product for the Tonopah Extension metallurgical work is determined solely by the amount of NaCN which it contains.

It is of interest to note that American imports of cyanide salts have been as follows:

Year.	KCN, Lb.	Value.	NaCN, Lb.	Value.
1912	1,138,569	$169,627	.....	.....
1913	1,023,167	143,999	.....	.....
1914	1,245,565	79,714	2,423,171[1]	$366,623
1915	872,207	134,210	4,178,058	650,559
1916	2,705	803	483,811	102,663
1917	104,316	76,303	1,604,117	803,604
1918	141,808	47,460	69,279	12,615
1919	1,176,345	68,848	5,174,831	305,426
1920	14,448,887	$1,088,247	7,590,495	1,091,443

[1] Six months.

It appears from the above figures that the Canadian cyanide is possibly coming in as the potash salt.

In January, 1921, the firm of Roessler & Hasslacher Chemical Co. appeared before the Committee on Ways and Means at Washington, D. C., and asked for a 33⅓-per cent. *ad valorem* duty on cyanide salts in order that American workmen might be protected. In the Hearings

[1] *Eng. Min. Jour.*, **110**, 614 (1920).
[2] *Eng. Min. Jour.*, **111**, 336 (1921).

published in April, there were several protests against the proposed tariff. The Homestake company, which uses 350,000 lb. of cyanide per annum, made a spirited protest, showing how it would be affected, and the whole mining industry likewise. Mr. Yates declared that the Canadian product (Aero brand) was the cheapest per unit of cyanogen, and its impurities were not detrimental. The Homestake was forced to seek other salts than those of the Roessler & Hasslacher company on account of the latter's exorbitant charges, which was said to be making a profit of 900 per cent. per annum. During the years 1914 to 1920, inclusive, the Homestake paid this firm 14½, 16, 25, 25, 30, 25½, and 21½ cts. per lb. f.o.b. Perth Amboy, N. J. For 1921 the firm charged 25½ cts., so the Homestake contracted with the American Cyanamid Co. at a much less rate. The results of the Tonopah Extension company, quoted on another page of this chapter, were mentioned. The American Cyanamid Co. also protested against the duty. It operates in Canada. The only manufacturer in America is Roessler & Hasslacher. The only other makers of cyanide salts are Cassel & Co. in Scotland and England, and the Deutsche Gold und Silber Scheide-Anhalt vormals Roessler in Germany. The Nevada Mine Operators' Association was confronted with a delivered price of 28½ cts. from Roessler & Hasslacher for 1921, so it closed with the American Cyanamid Co. at 23¾ cts. for part of its requirements and with Roessler & Hasslacher at 24¾ cts. for the balance. This competition has saved Tonopah companies 10 cts. per ton of ore treated because of a saving of 4¼ cts. per lb. on cyanide. There, 2½ lb. of cyanide dissolves 15 oz. of silver and gold per ton of ore. Over $100,000 is estimated to have been saved to gold and silver mining companies in American during 1920 by using the Aero brand salt. The American Cyanamid Co. considers that its process for making cyanide is not inferior to that of Roessler & Hasslacher. In 1910, 2000 tons of sodium cyanide was used in ore treatment and 2500 tons in other industries (fumigation, steel hardening, and electroplating), while in 1919 the figures were 1200 tons and 4000 respectively.

The California Metal and Mineral Producers Association petitioned Congress against the proposed import duty.

Estimation of oxygen in cyanide solutions may be made by the method devised by H. A. White of Johannesburg, in 1918. This depends on the degree of coloration imparted to a cyanide solution by the addition of pyrogallic acid and caustic soda. Standard solutions, showing the proper degrees of coloration, representing amounts of oxygen per liter, are prepared, but there are difficulties, such as fading; however, E. M. Hamilton[1] has found that a perfect color match during testing can be obtained

[1] *Eng. Min. Jour.*, **110**, 116 (1920).

by the use of a solution of caramel, which appears to persist for 3 to 4 weeks. He also found that the details of the method, as given by the inventor, must be modified to make it workable.

The Durban Roodepoort Deep, Ferreira, Robinson, and Village Deep mines pump a total of 1,800,000 gal. of water daily. Its natural acidity varies from 0.01 to 0.06 per cent., while the partly neutralized waters from these mines of the Central Rand contain 0.008 per cent. of free acid in terms of sulphuric, 0.357 per cent. suspended matter, and 0.005 per cent. ferrous oxide in solution. Such water was used in one of the mills. On contact with cyanide solution there was a loss of 2.58 lb. of KCN per ton of water, but on rendering alkaline to phenol, and filtering, the cyanide consumption was nil. Neutralizing agents are carbonate of soda, unslaked lime, slaked lime, and pulverulent carbonate of lime, according to F. Wartenweiler and E. H. Croghan.[1] Experiments were made on the sludge (precipitated matter) from water of the City Deep mine. It assayed 1.02 dwt. of gold per ton (this from fines from stopes), and almost 100 per cent. passed 200 mesh. A 2-in. cake could be formed on a vacuum-filter, but the best result was from a pressure filter-press. Deleterious reducing organic matter and ferrous salts caused a prohibitive consumption of cyanide when the sludge was treated by air-agitation in cyanide solution; but on a partly air-dried filter-press cake, a 90-per cent. extraction was recorded. This aeration had oxidized the ferrous iron to the ferric state. These investigations show that metallurgists should know exactly what class of water is used in the mill circuit, as erratic extraction may often be traced to this cause.

Regarding the recovery of silver from manganiferous silver ores, Jay A. Carpenter[2] says that the chloridizing-roasting of such ores has had the disadvantages of high loss of silver by volatilization and high costs; but with the improvement of furnaces and pyrometers, oil and powdered coal, and the Cottrell precipitation process, this method, plus cyanidation, may now be applied to dormant mines containing refractory silver ore. Mr. Carpenter has made a number of tests, which he describes, also the investigations being made by the U. S. Bureau of Mines and the Western Precipitation Co. A fairly complete bibliography of papers discussing this subject is attached.

Ores of the Oruro, Potosi, and Chocaya districts of Bolivia consist of a gangue of quartz and pyrite, carrying tin in the form of impure cassiterite, and silver in tetrahedrite, jamesonite, stibnite, and cylindrite, according to M. G. F. Söhnlein.[3] The sulphur content is 25 to 35 per cent., and silver from 25 to 50 oz. per ton. Prior to 1910, amalgamation

[1] *Jour. So. Afr. Inst. Engrs.*, Oct., 1919
[2] *Eng. Min. Jour.*, **110**, 898 (1920)
[3] *Min. & Met.*, **164**, 21 (Aug., 1920).

was employed to save the silver, but since then the process has been altered to dry crushing, chloridizing-roasting, and leaching the ore with water and hyposulphite solution, or with brine, to dissolve the silver, also the gold and copper. A straight-line, one-hearth Merton furnace, with five spindles and rabbles, is used. The salt for chloridizing the silver must be added at a certain point, just as all the sulphur has been converted into sulphates. There is always a more or less constant quantity of silver that cannot be converted into chloride. The percentage of chloridizing that can be obtained is not directly proportional to the silver content of the ore. From 3 to 5 per cent. of salt is added for 25 to 50 oz. of ore. The tin is concentrated after the leaching.

Progress continues to be made in the volatilization of ores. In Serial 2247 (1921) of the U. S. Bureau of Mines, Thomas Varley and C. C. Stevenson of the Utah Station discussed the latest phases. Metallurgists will remember the work of Croasdale, Howe, Cottrell, and Ralston. Patents granted so far are No. 1,262,453 to Clawson in 1918, No. 1,264,685 to Wigton in 1918, and No. 1,368,973 to Schmidt in 1921. The chloride volatilization process is especially adapted to treatment of oxide and semi-oxide and carbonate ores of lead, copper, and silver, difficult to treat by concentration. It is found that gold volatilizes readily, but zinc does not, if an oxidizing condition is maintained in roasting. No straight silver ore is treated. Silver-lead ore from Utah, California, Nevada, and South America, assaying 3½ oz. of silver and 15 per cent. lead, showed 87 to 75 per cent. of the silver to be volatilized. Results vary, as ore containing 12 oz. of silver and 1.6 per cent. lead gave 75 per cent. silver extraction, ore containing 9 oz. of silver and 15 per cent. lead gave 80 per cent., and ore containing 3.5 oz. of silver and 5.3 per cent. lead gave 87 per cent. The metals are recovered from the furnace fumes by the Cottrell electric precipitator. In the Schmidt roasting system, salt is added at every other hearth in a multiple-deck furnace. The patent, in brief, is as follows:

> The ore is heated, and a metallic chloride (sodium chloride or calcium chloride) is added to the ore during the heating operation in successive stages to cause volatilization of the metallic minerals in the ore (copper, silver, etc.), the resulting metallic fume being collected by electrical precipitation (Cottrell process), or otherwise. By this multi-stage volatilization, an increased amount of metallic minerals are volatilized for a given amount of chloridizing agent used.

The oxidized gold ore of the Connemara mine in Rhodesia occurs in what are locally termed "banded ironstones." The ore consists of fine-grained, alternating layers of iron oxides and granular quartz, with some magnesia and sulphates, according to B. L. Gardiner.[1] The

[1] *Jour. Chem. Met. Min. Soc. So. Afr.*, Jan., 1920.

average gold content is 6.76 dwt. ($6.76) per ton. It is very fine, and panning shows only 15 per cent. of the metal that is present. Amalgamation and cyanidation extracted only 68 per cent., but on separating out the fine ore (33 per cent. of the total), "baking" or heating for 30 min., then grinding through 200-mesh and cyaniding, it was found that extraction was increased to 86 per cent. Costs were little higher. The coarse ore was treated as usual. It is considered that the gold is locked up in the hydrated iron oxides, and the heat treatment alters them sufficiently to allow the cyanide to penetrate the ore. The mill treats over 4000 tons monthly.

Agitation

The simple expedient of attaching drag-chains to the arms of agitators in the United Eastern mill in Arizona increased the efficiency of the machines, at the same time reducing the consumption of cyanide.

Flotation

Under 100,000 tons of gold-silver ore is treated annually in the United States by flotation, according to Thomas Varley,[1] metallurgist in charge of the U. S. Bureau of Mines Experiment Station at Salt Lake City. Figures collected from a questionnarie showed that of over 26,000,000 tons of all ores floated during 1919, only 75,000 tons was gold-silver ore. Concentrates produced amounted to 8698 tons. Oils used approximated 1.25 lb. per ton of ore.

Francis A. Thomson of Idaho said[2] that approximately 5,000,000 tons of gold and silver ores are treated annually in the United States, but in this operation, flotation has not filled as important a place as its advocates predicted for it. Cyanidation, with lessening attention to amalgamation, still holds the field. Experiments show a high recovery from some ores by flotation, but the gold is so finely divided that 200-mesh grinding is necessary for its liberation, and floating 200-mesh is difficult. Many profitable gold mines are in remote places, prohibiting the shipment of anything but bullion. In complex ores, where the consumption of cyanide is high, or from which no good extraction can be made, flotation has a field. In the case of oxide ores of silver, where the primary sulphide ore is not amenable to flotation, it may be more profitable to sulphidize and then float the silver and other sulphides formed than to cyanide the oxide and float the sulphide.

[1] *Min. Sci. Press*, **122**, 262 (1921).
[2] Proc. Am. Min. Congress, 1920.

Precipitation

The technique of precipitation has advanced more in recent years that any other department of cyanidation, according to Allan J. Clark.[1] One pound of zinc dust now is as efficient as twice that amount was a few years ago. To obtain the full advantage of the improvements, extreme precision in the feeding of zinc is essential, and he explained by drawings how at the Homestake cyanide plants zinc dust is fed at rates ranging from 4 to 1¼ lb. per hour.

A problem in precipitation,[2] where zinc shaving was used, arose wherein on resuming work in a plant that had been idle for some time, the zinc functioned badly. After trying several correctives, it was found that after increasing the strength of the working solution, precipitation was good. It was thought that some salt was precipitated on the zinc, thereby preventing deposition of the gold. N. S. Keith[3] considers that the remedy is either to throw out all old remaining zinc from previous operations and use new shavings, or substitute precipitation by the zinc-dust method. When oxides and insoluble salts are deposited on zinc, and gold cannot be precipitated, the latter is re-dissolved, and flows through the box to the solution sump. Pregnant solutions should be de-aerated or de-gassed before precipitation, by the Crowe process, for instance.

Jay A. Carpenter's experience led him to remark[4] that the causes of poor precipitation are: (1) muddy solutions; (2) excessively aerated solutions; (3) absence of free cyanide; (4) absence of any protective alkali, giving free HCN in the solutions; (5) considerable copper in solutions; (6) excess of alkaline sulphides, etc.; and (7) a coating of zinc oxide on the zinc, either from long standing in solutions or in the air. J. A. Diehl followed this by saying[5] that cyanide solution will attack copper phosphate, taking the copper into solution, while the phosphate forms an alkaline phosphate. Nascent hydrogen generated in the zinc-box then evolves phosphine, which attacks the gold solution, precipitating the gold in a fine amorphous state. Where there is copper in the ore, Mr. Diehl suggests the use of zinc dust instead of shavings.

Colloidal silica has a considerable effect on precipitation, according to J. H. Johnson,[6] who analyzed a deposit on zinc shaving in a precipitation box. This contained 22.8 per cent. soluble silica, 26.4 calcium oxide, 18 combined water, 18 carbon dioxide, and 9 per cent. zinc oxide. The deposit was therefore practically composed of calcium carbonate and

[1] *Eng. Min. Jour.*, **109,** 862 (1920).
[2] *Eng. Min. Jour.*, **109,** 708 (1920).
[3] *Eng. Min. Jour.*, **109,** 808 (1920).
[4] *Eng. Min. Jour.*, **109,** 1200 (1920).
[5] *Eng. Min. Jour.*, **110,** 52 (1920).
[6] *Jour. Chem. Met. Min. Soc. So. Afr.*, Oct., 1920.

gelatinous silica containing water. The mixture was readily soluble in dilute acids, but if the solution was heated, neutralized, etc., the colloidal silica at once assumed the gelatinous form and was deposited. The silica formed an impermeable coating on the zinc and prevented precipitation. If the solutions entering the boxes were perfectly clear, it is apparent that the silica must exist in the colloidal sol form, and be deposited on the zinc in the gel form by chemical or galvanic disturbance. A scum found at the head and between compartments of the precipitation boxes was practically the same as the deposit. Two samples of so-called white precipitate, one from the East Rand and one from West Rand, showed on examination that they carried 37.95 and 38.75 per cent. silica, respectively, which was found in a very fine state of division, almost gelatinous. The foregoing instances fairly demonstrate that colloidal silica has a considerable effect on precipitation. In connection with all these cases, considerable trouble was experienced in the clean-up filter-press, the silica forming on the filter-papers in a gelatinous film, almost impervious to water, and causing a rapid rise in pressure on the press.

Practically nothing was written during the year about the Crowe vacuum process as an aid to precipitation, but it is known that where the apparatus was installed, results were very satisfactory. The annual report of the United Eastern company at Oatman, Ariz., stated that zinc consumption was lower, due to the vacuum process.

The Crowe process is the one outstanding novelty advanced during recent years according to Alfred James.[1] It goes back to early practice, the exhaustion by vacuum of all solutions after lixiviation and prior to precipitation, as adopted in every plant known to him which was laid down by the patentees and their trained chemists during the whole life of the cyanide patents. In all early plants, solutions to be precipitated were led to the precipitation boxes protected from access of air: the effluent, on the contrary, was always arranged to cascade from a height into the sumps.

Referring to the Crowe patent, Mr. James asks why should not a man be allowed to derive benefit from his application, to a new purpose, of an old known apparatus or method? He introduced the vacuum chamber to the cyanide process. He had no thought but of assisting filtration, nor until Crowe's message had he knowledge from any one of the great benefit which has since been proved to result from the application of Crowe's method. Advantage should not be taken of an inadequate patent law, but due reward should be given to the man who has done so much to improve zinc-box practice and to relieve operators of the worry resulting from white precipitate and other troubles. The results reported

[1] *Eng. Min. Jour.*, **111**, 102 (1921).

from Mexico and elsewhere are remarkable. At one mine there is no saving in cyanide, but an extraordinary reduction in the consumption of zinc to less than one kg. of zinc to one of silver. This may be overdone. The partly precipitated solutions at this mine carry double their previous silver content. It will probably pay to use a little more zinc and to lose a little less silver in circulation. But just as the dilution of solution was for a time overdone at the Robinson mine in South Africa without detriment to the cyanide process itself, so the heavier silver content of certain solutions at Pachuca is no detriment to Crowe's discovery. The least amount of zinc for the greatest recovery of silver will adjust itself in time. Mr. James is the inventor of the precipitation or zinc-box, but did not patent or draw any royalties from users of this important adjunct to cyanide plants.

Allan J. Clarke,[1] metallurgist for the Homestake Mining Co., considered that Mr. James' argument was "rendered futile" when the latter discussed the "consumption of 0.407 lb. of zinc per ton of ore," etc., as during 1920 the Homestake cyanide plants, in treating 1,255,419 tons of tailing, consumed 50,133 lb. of zinc dust, equal to only 0.04 lb. per ton of tailing.

Metallurgists who use aluminium dust for precipitation will find the three articles[2] on the analysis of that metal, by J. E. Clennell, of much value. The methods, which require considerable study, are classified as gravimetric, volumetric, and gasometric. The last mentioned is only used for aluminium dust or alloys.

The approximate consumption of zinc on the Rand is 0.1 lb. per ton of cyanide solution, carrying 2 dwt. ($2.00) of gold per ton. The points where this consumption takes place are as follows, according to H. A. White,[3] who considers present methods of gold precipitation as wastefully inefficient:

	Per Cent.
Gold and silver precipitation	1.2
Combination with dissolved oxygen	49.0
Evolution of hydrogen	4.8
Taken for clean-up	33.0
Used to precipitate lead in "dipping," waste in cutting, used in forming ZnS coating, etc.	12.0
	100.0

Mr. White made tests to observe the various conditions that in practice might affect the consumption of zinc, and particularly the concentration of cyanide, alkalinity, and oxygen present.

Under the late S. B. Christy, the University of California at Berkeley has been investigating electrodeposition of gold and silver from cyanide solutions at intervals for 20 years. Bulletin 150 of the U. S. Bureau of

[1] *Eng. Min. Jour.*, **111**, 496 (1921).
[2] *Mining Mag.*, **22**, 88, 152, 216 (1920).
[3] *Jour. Chem. Met. Min. Soc. So. Afr.*, Dec., 1919.

Mines, which maintains an experiment station at the University, detailed the results of the investigations, and these were reviewed by J. E. Clennell.[1] Christy secured a patent[2] in 1900 for "progressive electro-concentration and recovery of gold and silver in dilute cyanide solution . . ." Mr. Clennell concludes that the process is of great interest from a scientific point of view, and perhaps contains possiblities which might be developed into a system of practical value, but apart from some regeneration of cyanide, the process has no advantage over modern systems of precipitation, added to which is a larger cost of installation, and employment of more and skilled labor.

On the other hand, Douglas Lay considers[3] that, after exhaustive working tests, electric precipitation of gold from solutions has the advantage of (1) a small amount of skilled labor; (2) ease and cheapness of clean-up; and (3) low consumption of energy. The only appreciable charge is the wear of anodes. It is also claimed that the electric current exerts a beneficial action in aiding solution of the precious metals.

Clean-up and Melting

Copper dissolved from the ore of the Oroya Black Range mine in Western Australia was the cause of several difficulties during clean-up, according to W. B. Chomley.[4] The main trouble arose through the corrosive action of the roasted zinc-gold precipitate, or really the oxidized copper, on the plumbago crucibles. The most suitable flux was 100 parts roasted precipitate, 40 parts borax glass, and 5 parts silica. Crucibles rarely lasted more than one melt; sometimes they ran through during the first charge. Attempts were made to remove the copper from the precipitate prior to melting, with sulphuric acid and nitric acid; but on a working scale this was impracticable. Finally, the problem was solved by not roasting, and feeding damp precipitate and fluxes into the hot crucible. This method was quite successful, as crucibles lasted over three months and the bullion was not appreciably of lower fineness than before.

General

The accompanying flow-sheets illustrate the method of treating $5 ore at the Belmont Shawmut gold mine in Tuolumne County, California, as described by A. B. Parsons.[5] This mill was remodeled in 1917, and now employs flotation machines, the ore being a sulphide. The main feature is the local treatment of concentrate, once sent to the smelter.

[1] *Mining Mag.*, **23**, 22, 81 (1920).
[2] U. S. Patent No. 643,096.
[3] *Eng. Min. Jour.*, **110**, 58 (1920).
[4] *Month. Jour. Chamber of Mines*, Sept., 1920.
[5] *Min. Sci. Press*, **121**, 659 (1920).

Normally, 400 tons of ore produces 13 tons of $25 flotation concentrate. This is sent to a Butchart table, which makes 2 tons of $60 sand, 9 tons of $25 slime and 2 tons of $2.50 tailing. The first product joins the regular table concentrate, while the slime is later mixed with roasted concentrate and cyanided. The whole mill makes about 23 tons of concentrate per day, and this is treated in the plant of which the accompanying is a flow-sheet. Each furnace roasts 6 or 7 tons daily. Fuel-oil is used for firing. The agitators treat a mixture of roasted concentrate and the slime previously mentioned. This seems peculiar practice, but extraction is 91 to 94 per cent., against 90 to 92 per cent. on the roasted

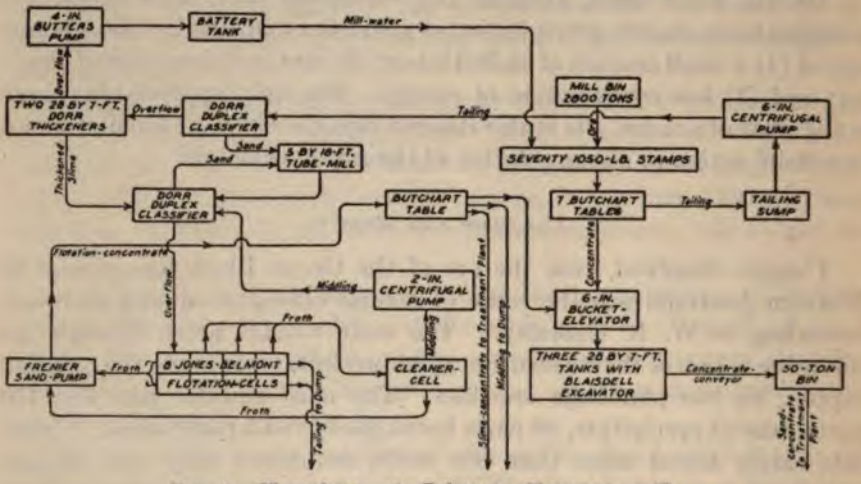


FIG. 6.—Flow-sheet of Belmont Shawmut mill.

product, and 60 per cent. on the raw slime alone. Cyanide consumption averages 1.4 lb. per ton of concentrate, and lead-acetate consumption 0.3 lb.

At Calico, San Bernardino County, California, is the Daggett R. & M. Co.'s cyanide plant, erected to treat 200,000 tons of silver-bearing tailing. It is entirely without "frills," according to Leroy A. Palmer,[1] due to the owners' being obliged to make the best of the material at their disposal. Ores of this district were mainly chlorides and bromides of silver in a gangue of quartz and barite. They were treated by the Boss system of pan-amalgamation. The tailing carries 3 to 6 oz. of silver, 60 cts. gold and 0.5 lb. of mercury per ton. The plant treats 75 tons in two 8-hr. shifts. The feed is flushed into the vats in cyanide solution and slime is separated from the sand therein by simply building up the sand to one side. The sand is treated by leaching, and the slime by

[1] *Eng. Min. Jour.*, **109**, 1260 (1920).

straight decantation. Zinc shaving is used for precipitation. Extraction is 78 per cent. of the silver, 30 per cent. of the gold, and 15 per cent. of the mercury, rather low due to the presence of amalgam. Cyanide consumption is 0.3 lb. per ton treated, and lime 1 lb. Costs are only 68 cts. per ton, creditable work.

The Benguet Consolidated is the most important gold mine in the Philippines, and its policy has always been a progressive one. Milling practice was detailed by C. M. Eye and M. F. Dold[1] during the year. The first of the two papers was mainly historic and on development of methods. The first work was done in 1905. Ore is a mixture of quartz, iron oxide and sulphide, altered diorite and clay. The first mentioned predominates. There is some free gold, but none is visible. The ratio of gold to silver is 3 to 1. The annual production is close to 900,000 pesos ($450,000), of which 400,000 pesos is profit. Good dividends are paid. In crushing, it was found that the motor-driven breaker worked better with a short center drive than the former long drive. The ten stamps are driven by a 25-hp. back-geared motor. The drop is 7½ in., 106 times a minute. A locally made drag-classifier, consisting of 5-ply balata belt, 8 in. wide, with 2-in. angle iron bolted to it, gives much satisfaction. It removes most of the coarse material for delivery to the tube mills. These are 6 ft. in diameter and 10 to 12 ft. long. Mine rock is used with flint pebbles. The relative cost is $2 or $3 and $75 per ton. Cyanide is added at the head of the tube mills. Belt and bucket elevators for handling wet pulp are considered the best means of doing this work. Primary thickening is done in two thickeners, one preceding and one following the first agitator. The overflow from the first normally furnishes 75 per cent. of the flow for precipitation purposes. Agitation is accomplished by Trent and Dorr machines. Following these are the

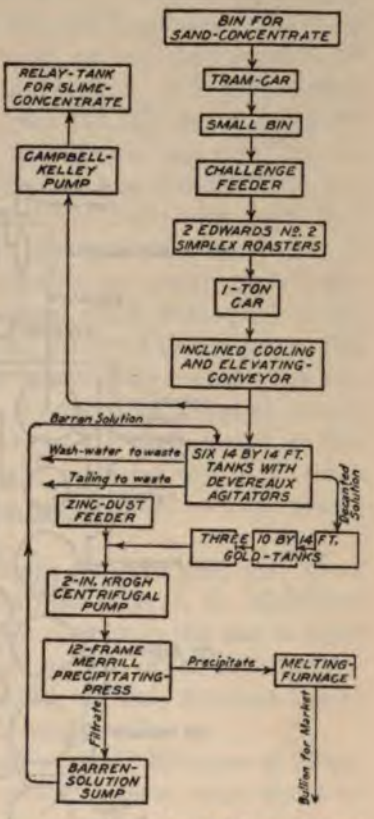


FIG. 7.—Flow-sheet of Belmont Shawmut cyanide plant.

[1] *Min. Sci. Press*, **121**, 805 and 841 (1920).

secondary thickening and decantation apparatus, Trent replacers and Oliver filter for final filtration of slime. Precipitation of gold is on zinc shaving, cut from sheet in the mine. A little lead acetate is added to the boxes. Pregnant solution assays $3 to $4 per ton, and the outflow a few

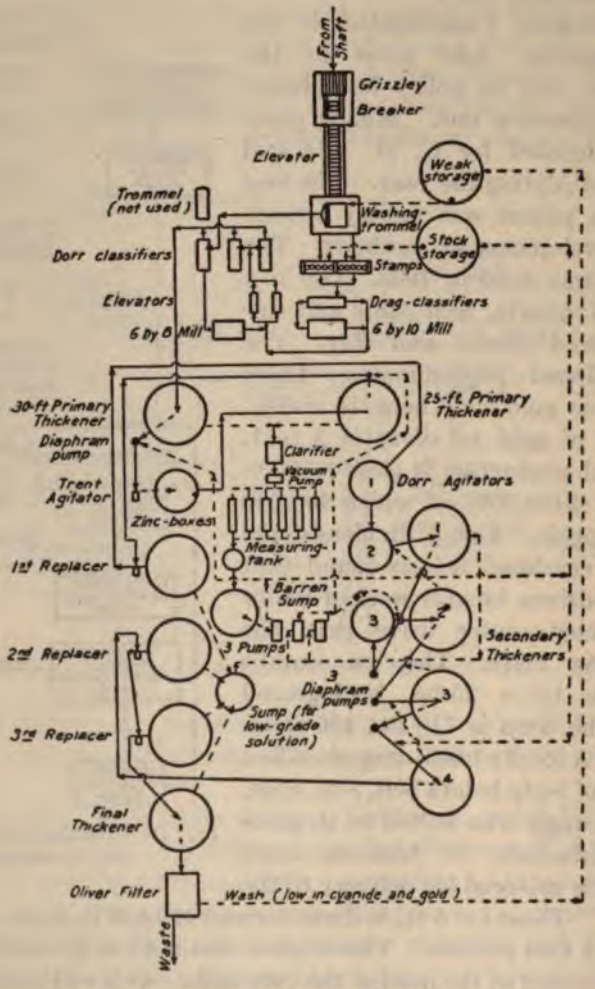


FIG. 8.—Flow-sheet of Benguet Consolidated mill.

cents. Clean-up and melting present no unusual practice, and yields bullion 600 fine in gold and 250 in silver. Consumption of cyanide is 1 lb. per ton of ore treated.

One of the most peculiar gold deposits being worked is that of La Luz & Los Angeles Mining Co., not far from the Eden mine in the Pis Pis

district of Nicaragua. According to Jesse Scobey,[1] it is a surficial deposit, about 1000 ft. long, 300 ft. wide, and 100 ft. deep, occurring in a highly fractured contact-metamorphic limestone. Sulphides are almost negligible, and carry no gold. The "dirt" or ore has been very soft. From 1901 to 1920 there was broken 540,145 tons of $8.15 ore, this to a depth of only 60 ft. Huntington mills were used from the beginning, there being six in 1914. These crushed through 24-mesh screens, and reduced 20 tons each per day. They were entirely satisfactory, and, with copper plates, recovered 66 per cent. of the gold from 440,145 tons of $9.20 ore milled during 19 years. Of the amalgam, 65 per cent. was saved by the mills and 35 per cent. on the plates. Quicksilver loss was 0.0097 lb. per ton of ore during a period of 5 years. Since it was found with depth that the ore was too hard for the Huntingtons, five stamps were started in 1914, and by 1918 the comminution was done by ten stamps, one Hardinge ball and two pebble mills. The stamps crush through 4 mesh. Drilling at the mine showed that the deposit persisted to a depth of 500 ft., carrying average gold content, but was harder than near the surface. Tests on the ore showed that cyanidation is applicable; flotation is not. Bullion is 830 fine, and an export tax of 53 cts. (U. S.) is levied on this grade. While this company has solved many problems with skill, there have been few real difficulties with mining and milling, and operations have been highly profitable.

In comparing the metallurgy of Northern Ontario gold and silver ores, more particularly at Cobalt, in 1914 and 1920, J. G. McMillan considered[2] that progress at Cobalt was due mainly to the rise in price of silver. As an instance of the lower silver content of the ore, the McKinley-Darragh mill treated 47-oz. ore in 1910, but only 11.81-oz. ore in 1920. Following are the changes in the Coniagas mill:

1914: Straight concentration; 60 stamps crushed 180 tons of 20-oz. ore daily, plus high-grade ore; 14-mesh sand and slime went direct to waste from the tables.

1920: Concentration plus flotation; 60 stamps crush 300 tons of 10-oz. ore, with no high-grade ore; 3-mesh pulp goes to tables, and coarser than 100 mesh is re-ground in tube mills preparatory to flotation; 1-oz. tailings go to waste.

Flotation was introduced in 1916; 150-oz. concentrate has been increased to 450-oz. by this system.

[1] *Eng. Min. Jour.*, **110**, 6 (1920).
[2] Paper read at annual meeting of Can. Min. Inst., March, 1920.

GRAPHITE

By Benjamin L. Miller

In many respects the year 1920 was the most disastrous one in the history of the graphite industry. The reaction from the banner years of 1917 and 1918 brought hardship to many operators during 1919, but not to the extent they suffered in 1920. Notwithstanding the figures which in several instances show increased sales over those of 1919, the depression was more seriously felt and prices averaged about 50 per cent. lower. Throughout the entire year there was great apprehension among the producers with reference to the future.

The prime cause for the depression was the decreased demand for crucible graphite for the reason that the greater portion of the production of crystalline natural graphite of the world in recent years has gone into the manufacture of crucibles. It has been estimated that the proportion so used may even be as much as 75 per cent. During the war the unusually large amount of crucible steel and various alloys required in the manufacture of war materials called for unprecedented amounts of graphite and stimulated production in almost every graphite district of the world. When the armistice was signed, the principal manufacturers of graphite crucibles had on hand large supplies of crucibles as well as heavy stocks of graphite, and the graphite producers likewise held larger amounts of unsold refined graphite than at any former period. At once the demand for crucibles diminished and the market price of the raw graphite fell below the cost of production. A number of companies continued to produce graphite during 1919, thus adding still further to the stock on hand, but one by one companies ceased operation until there were but few producing concerns at the beginning of 1920 and still fewer at the close of the year. During 1920 the accumulation was gradually being consumed, although considerably more time will be required for its entire consumption. Thousands of tons of Ceylon, Madagascar, and domestic flake graphite remained unsold at the close of 1920; consequently the revival of the industry has been delayed.

It is now generally recognized that the post-war demands for graphite fall far below the production capacity of the plants in operation during 1917 and 1918, a condition similar to that prevailing in several other branches of the mineral industry. Attempts to stimulate the increased use of graphite articles do not afford much promise and in fact there is danger of a decreased demand due to the substitution of electric-furnace

steel for crucible steel. The inevitable result is that prices must fall to the point where only the plants most advantageously situated can continue to operate. It is not difficult to name certain companies that will not be able to withstand competition, but the contest will doubtless result in further improvements of mining and milling and the final results are still in doubt.

Prices

With reduced market demands the price of graphite was lower during 1920 than for a number of years past. There was no steady market for the product and there were a number of forced sales at abnormally low prices, thus making it difficult to determine the prevailing normal prices for the year.

Lump Ceylon graphite sold in Colombo for 7 cts. per lb., and in New York for 8½ cts. Madagascar flake, 85 per cent. carbon, sold in New York as low as 4 cts. per lb., although the average price was somewhat higher. The average price for domestic flake graphite was slightly less than 6 cts. per lb. with a probable average carbon content between 85 and 90 per cent. This represents a reduction of about 33 per cent. in comparison with the prices of 1919, while the production costs remained practically the same.

The amorphous graphite produced in Rhode Island, Nevada and Colorado averaged $10.60 a ton, a reduction of 25 per cent. as compared with the 1919 prices.

Graphite Production in the United States

The quantity of domestic flake and amorphous graphite sold by producers in the United States in 1920 amounted to 9,510 short tons, an increase of 28 per cent. over the quantity sold in 1919. The value of the graphite sold in 1920 was about $626,201, as compared with $778,857 in 1919. These figures are based on reports made by producers to the U. S. Geological Survey.

Operators in Colorado, Nevada, and Rhode Island reported sales of 4,694 short tons of amorphous graphite in 1920 at an average price of $10.60 a ton. This was $3.52 per ton less than the average price in 1919.

The sales of crystalline graphite in 1920 amounted to 9,632,360 lb., valued at $576,443, as compared with 8,086,191 lb. valued at $731,141 in 1919. The average price per pound in 1920 was 5.9 cts.; in 1919 it was 9 cts. Alabama led in the production of crystalline graphite, the sales in 1920 amounting to 4,894,648 lb., or 51 per cent. of the total quantity sold in the United States. The sales reported from New York and Pennsylvania amounted to 3,552,687 lb., or 37 per cent. of the total in the United

States, and the remaining 13 per cent. was reported from California, Montana, and Texas.

The Acheson Graphite Co. reported the sale of 7,399,749 lb. of artificial graphite, which it manufactured at its plant at Niagara Falls, N. Y.

STATISTICS OF GRAPHITE IN THE UNITED STATES

Year.	Refined Crystalline Graphite.						Amorphous Graphite Production.	
	Production.		Imports.		Consumption. (a)			
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Short Tons.	Value.
1904	4,357,927	$162,332	25,350,000	$905,581	29,707,927	$1,067,913	19,115	$ 102,925
1905	4,260,656	170,426	34,914,611	983,034	39,175,267	1,153,460	21,953	80,639
1906	4,894,483	170,866	50,974,336	1,554,212	55,868,819	1,725,098	16,853	(b)
1907	4,586,149	149,548	40,962,000	1,777,389	45,548,149	1,926,937	26,962	138,381
1908	3,433,039	149,763	22,912,714	762,267	26,345,753	876,030	1,433	75,250
1909	5,669,899	340,194	42,532,851	1,854,459	48,202,750	2,194,653	5,096	32,238
1910	5,625,132	286,882	50,610,560	1,872,592	56,235,692	2,159,474	1,407	39,710
1911	4,790,000	256,050	41,404,000	1,495,729	46,194,000	1,751,779	1,223	32,415
1912	3,543,771	187,689	51,286,000	1,709,337	50,188,969	1,553,568	2,063	32,894
1913	5,064,727	254,328	57,758,400	2,109,791	57,439,146	1,972,213	2,243	39,482
1914	5,220,539	285,368	44,004,800	1,398,261	45,304,646	1,406,243	1,725	38,750
1915	7,074,370	417,273	46,155,200	2,241,163	52,163,866	2,605,420	1,181	12,358
1916	10,931,989	914,748	86,033,920	7,279,884	95,370,301	8,096,514	2,622	20,723
1917	10,584,080	1,094,398	85,218,000	8,961,988	90,655,264	9,706,823	8,301	73,481
1918	12,861,839	1,454,799	38,996,160	3,092,475	49,950,280	4,425,719	6,560	69,455
1919	8,086,191	731,141	53,251,520	2,978,096	60,079,671	3,619,052	3,379	47,716
1920	9,632,360	576,443	42,190,400	1,711,312	50,609,144	2,174,984	4,694	49,758

(a) Production (sales) plus imports minus exports. (b) Not reported.

Production of Manufactured Graphite

Year.	Quantity, Pounds. Made in Canada.	Made in U. S.	Value.	Price per Pound, Cents.
1899	.....	405,870	$32,475	8.00
1900	.....	860,750	68,860	8.00
1901	.....	2,500,000	119,000	4.76
1902	.....	2,358,828	110,700	4.69
1903	.....	2,620,000	178,670	6.82
1904	.....	3,248,000	217,000	6.70
1905	.....	4,595,500	313,979	6.83
1906	.....	4,868,000	312,764	6.42
1907	.....	6,924,000	483,717	6.97
1908	.....	7,835,511	520,667	6.80
1909	.....	6,870,529	467,196	6.80
1910	.....	13,149,000	945,000	7.19
1911	.....	10,144,000	664,000	6.54
1912	.....	12,896,347	830,193	6.44
1913	.....	13,633,342	973,397	7.14
1914	.....	10,455,139	698,800	6.68
1915	(a) 497,271	(a) 5,083,166	109,102	1.96
1916	(a) 525,048	(a) 8,397,281	.....	....
1917	(a)1,096,172	(a)10,474,649	.....	....
1918	(a)1,808,698	(a) 9,182,272	.....	....
1919	(a) 358,524	(a) 8,163,177	.....	....
1920	.....	(a) 7,397,749	.....	....

(a) Powdered graphite only; electrode material not included.

Conditions in the United States.—The graphite industry of the United States during 1920 was in a demoralized condition, although not hopeless. The chief efforts of the producers were directed toward securing an import tariff on graphite, thus eliminating the present foreign competition. Many domestic operators freely declare that they cannot compete with the Madagascar product that is similar in character, but mined and con-

centrated at very low costs, unless Congress imposes a high import tariff. The best grades of Ceylon graphite with a much higher percentage of carbon also militate against the use of domestic flake in the manufacture of crucibles, especially with such prices as prevailed during 1920.

Should the efforts to obtain an import tariff fail, some operators maintain that it is possible to so perfect the concentrating and refining methods as to reduce the costs to a point where competition with the foreign producers will not be detrimental. The use of oil-flotation processes, especially the Callow process, is proving to be so successful that there are reasons to believe that these operators are justified in their belief.

Another favorable outlook is based on the experimental work of the Bureau of Mines in the utilization of domestic flake in crucible manufacture. Although the results obtained thus far are not conclusive, there is some encouragement to believe that it may eventually be demonstrated that the crucibles made mainly or entirely of domestic flake will prove as serviceable as those now made with Ceylon lump, although the crucible manufacturers generally maintain that this is not possible because of the different physical characters of the two varieties.

In several sections the idea of the producers also becoming the manufacturers of graphite articles is gaining favor. It is held that the manufacturers are receiving an undue share of the profits of the graphite industry, which is probably true, but the difficulties are so great that the day seems far distant when such a district as that of northern Alabama will be sending manufactured graphite articles into the market. The suggestion seems to be futile and a more reasonable one would be an attempt to establish more cordial relations between the producer and the manufacturer.

Marketing of Domestic Graphite.—The marketing of graphite has been somewhat haphazard in the past and few attempts have been made to systematize it. In the first place almost every company operating in a graphite district has produced material of different quality and also the product from any one mill may vary greatly at different times. The manufacturers of graphite products have been hampered by this variation and probably for this reason mainly have acquired a prejudice against the domestic flake graphite. The Alabama Graphite Producers Association realized the importance of standardizing the Alabama product and took measures to have all the material produced by the members of the Association carefully sampled and assayed by a reliable chemist before being shipped from the district. Where this has not been done there have been

many cases of shipments being declined by the manufacturers or accepted at lower prices than that agreed upon, because they did not meet the specifications or were of lower grade than the sample previously submitted. Unpleasant disputes and serious losses can be traced to this lack of uniformity of the marketed product, but this defect is now fully realized by the operators and is being remedied.

The irregularity of the supply has also been a drawback in the domestic graphite industry. Operators have made contracts to furnish definite amounts regularly and due to mill defects have been unable to meet their obligations. For that reason manufacturers have experienced difficulty in dealing directly with the operators. Where they have continued to do so they have found it necessary to lay in large stocks when the product was available and then for a number of months would not be in the market to buy any graphite. Thus the operating companies with small working capital have frequently suffered financial difficulties because of their inability to dispose of their product promptly.

All of these conditions have resulted in the development of the middlemen, who have been ready to buy anything offered by the operators and by the proper refining, blending, and classifying furnish to the manufacturers any grade of material desired and of guaranteed quality. Naturally these middlemen take advantage of any forced sales. On the whole they have tended to stabilize the industry, as they are practically always ready to buy and thus relieve the financial distress which a company may encounter and also they are able to furnish a dependable supply to the manufacturer. Notwithstanding this the operators have long complained that these middlemen are receiving excessive profits and depriving the operators of their just returns. These same dealers are apt to be also importers of foreign graphite and have been accused by the operators of playing the foreign producer against the domestic producer in order to beat down the price and purchase to the best advantage.

IN 1920

GRAPHITE IMPORTED INTO THE UNITED STATES IN 1920

Country of Origin.	Quantity. (Short Tons).	Value.
Ceylon	9,204	$1,077,290
Madagascar	4,710	286,383
Canada	2,170	157,015
Brazil		
Mexico	3,659	131,832
Chosen (Korea)	810	20,936
Italy	137	5,072
Austria	58	1,195
Germany	30	2,502
Other countries	317	20,087
	21,095	1,711,312

Alabama.—Notwithstanding the fact that Alabama supplied 51 per cent. of the domestic graphite marketed during the year, the industry was at low ebb. Only a few companies operated their plants at all, and at the close of the year there was practical stagnation throughout the district. The Quenelda Graphite Corporation, formed by the consolidation of the American, Crucible Flake, Quenelda, Carbon Mountain, and Peerless companies, operated its Carbon Mountain and Peerless plants most of the time throughout the year, and the refinery in Lineville completed early in the year was likewise in operation. It reports a production of 3,700,000 lb. of graphite with 200 tons of unfinished wet concentrates on hand. This company, the Superior Flake Graphite Co. of Clay County, and the Ceylon Co. of Coosa County were the only ones in operation during the latter part of the year. The mill of the Flaketown Graphite Co. of Chilton County was rebuilt and about ready to operate at the close of the year.

The Alabama producers with an investment of approximately $6,000,000, an almost unlimited supply of 3-per cent. graphite ore, and sufficient mills to furnish all the graphite required in the United States, have been especially active in agitating for a protective tariff. They report a reduction of 20 per cent. in the cost of labor, but this was largely counterbalanced by the increased freight-rates. A number of companies have on hand considerable stocks of refined graphite which was produced under high labor costs and for which there has been no market.

New York.—The conditions in New York during 1920 were similar to those in the other states. The American Graphite Co.,[1] with its mine and concentrating mill at Graphite, six miles from Hague on Lake George, and its refinery at Ticonderoga, continued to be the principal producer of the State. Two beds of graphite quartz schist have been developed there, although only the lower one with an average thickness of 20 ft. is being worked. It is said to average 6 per cent. graphitic carbon. Some years ago the main orebody was lost due to faulting, but the continuation was located and a 12-years' supply has been proved by drilling. In recent years the concentrating mill has been re-fitted with gyratories, rolls, and ball mills for crushing and grinding and Callow oil-flotation cells to replace the stamp mills and buddles formerly used. The mill, operating 24 hr. per day, grinds and concentrates 100 tons per day and recovers more than 87 per cent. of the graphite. The concentrates average 96½ per cent. graphitic carbon while the coarse concentrates average as high as 91 per cent.

Frank C. and George Hooper, long interested in the graphite industry of New York and Alabama, operate a mine and mill about 5 miles from

[1] C. E. Chaffin, *Min. Sci. Press*, Apr. 17, 1920, pp. 567–569.

Whitehall, north of South Bay, Lake Champlain. The plant was closed during most of 1920. A hydro-electric plant on the property is planned.

Pennsylvania.—There was little work done in the graphite district of Chester County, Pennsylvania, during 1920 and all operations ceased during the latter portion of the year.

Montana.—The deposit near Dillon, Mont., was operated for a short time only during 1920.

Texas.—The Llano-Burnet district of central Texas furnished a small amount of graphite during the year, but the activities of the three companies of that district were much reduced.

Massachusetts.—Some graphite production is reported from the old graphite mine in Sturbridge, Mass., during 1920 and plans were formulated for greater production in 1921.

California.—A small amount of graphite was produced in California in the vicinity of Los Angeles. The material is partly amorphous.

Rhode Island, Nevada, Colorado, and Michigan.—As in former years these States produced amorphous graphite. Rhode Island is the principal producer; the material is used mainly for foundry facings. The graphitic schist mined at L'Anse, Mich., is used for paint.

Graphite in Foreign Countries

Canada.—(By Hugh S. Spence.) The year was a dull one, and with the exception of the Black Donald mine, in Ontario, and the Quebec Graphite Co.'s mine, at Buckingham, Que., practically all the properties were idle. The dull market for all grades of flake and the stagnation in the crucible business offered little inducement to Canadian operators to work their properties. Probably not more than half a dozen cars of No. 1 flake was produced during the year. A new Ontario producer, commencing operations in 1919, reported having made a quantity of crucible stock in that year, which has not been sold to date.

The Black Donald mine, at Calabogie, Ont., ran, as usual, all year. This mine, which is developing probably the largest deposit of flake graphite known, produces chiefly the finer sizes, and thus is not directly affected by the crucible trade. The Callow system of oil-flotation, installed here two years ago, has proved very successful, the company reporting that mill-run assays of 98 per cent. carbon are consistently obtained for their best grades. The same system of refining has been installed at the mills of the Quebec Graphite Co. and the Consolidated Graphite Mining and Milling Co., both at Buckingham, Que., and results are reported as being eminently satisfactory. There is no doubt, therefore, that a satisfactory method of treating Canadian flake graphite ores of all types has at last been found. Unfortunately, it has arrived

at a time when general depression of the market and uncertain industrial conditions are seriously hampering the graphite industry on this Continent; and until the situation undergoes a material change for the better, little advantage can be taken by producers in general of what the process has to offer.

The Quebec Graphite Co. is endeavoring to enter the market with a line of various graphite products, such as greases, stove-polish, dry lubricating graphite, boiler graphite, paints, etc., most of which articles up to the present time have had to be imported from the United States. The Dominion Crucible Co.'s plant at St. John's, Que., was idle all the year.

The shipments of Canadian graphite, according to preliminary statistics of the Government, amounted to "a total of 2,227 tons valued at $173,537, which included 234 tons of No. 1 flake valued at $483,612; 234 tons of No. 2 flake valued at $28,512; and 1769 tons of No. 3 and dust valued at $96,663. Of the total Quebec contributed 233 tons valued at $31,913, and Ontario 1994 tons valued at $141,624." The production was considerably greater than during 1919, but a great reduction from the banner year of 1917.

Ceylon.—The following review of the graphite situation in Ceylon in recent years by U. S. Consul Robert L. Keiser is taken from *Commerce Reports* for Jan. 12, 1921.

"The plumbago trade of Ceylon reached a minimum in 1919, having dropped from an exportation of over 33,000 tons in 1916 to 6671 tons in 1919. The first five months of 1920 show a slight increase, 4235 tons having been exported, valued at 973,701 rupees. Of this amount the United States took 2800 tons valued at 73,000 rupees, or about 70 per cent. of the total. Exportation for the last four years has been as follows, in long tons:

Countries.	1917 (Tons).	1918 (Tons).	1919 (Tons)	Five Months of 1920 (Tons).
United States	21,965	8,178	3,995	2,800
United Kingdom	4,600	6,386	2,260	1,062
India	145	293	88	31
Australia	237	288	146	188
Japan	.....	61	80	117
All other	200	11	102	37
Total	27,047	15,217	6,671	4,235

"The great slump in exportation has led to the closing of the majority of the small mines. During the peak of production (1917) about 1300 mines were in operation, but at the beginning of 1920 less than 50 mines were working. It should be noted, however, that most of the mines in

operation are those which are able at short notice, or with little preparation, to mine the bulk of the production. These belong to the wealthier operators, who find it advantageous to have their mines producing sufficiently to cover necessary maintenance costs—principally operation of pumps to prevent flooding. Some of the mines are also increasing the number of galleries to the different leads, thereby increasing potential production. The number of curing yards in Colombo has diminished from 140 to about 30.

"The average value per ton of all grades of plumbago exported in 1913 was $110 (330 rupees) and in 1917 about $300 (900 rupees.) In 1918 this figure decreased to about $100 (300 rupees); in 1919, to $104 (260 rupees); in 1920, to $165 (320 rupees). It is difficult to estimate these values in terms of dollars, owing to the rapid fluctuation of exchange.

"It is interesting to note that in 1913 the average value of plumbago exported to the United States, the United Kingdom, and Germany (these being the three largest consumers in the order named) was about the same for each of these countries. In 1918 the average value of the plumbago exported to the United States was about $130 per ton, against $80 for the United Kingdom, and a general average of $100. In 1919 the imports to the United Kingdom averaged $70 per ton, while those to the United States were valued at $130, the general average having been $105. Statistics for the 1920 period show that the average values of exportation to the United Kingdom and the United States are again about the same, namely $108 and $113, respectively.

"The Plumbago Merchants' Association some time ago made efforts to obtain a permanent market at fixed prices through offering contracts abroad for fixed periods, but nothing came of the matter. Efforts were also made to obtain Government assistance through subsidies and preferential tariffs to insure steady production and outlet. Neither of these has obtained Government sanction.

"No statistics are available covering production costs. The producers claim that on the present basis of prices there is not sufficient profit to make production interesting to them. Since 1913 wages have increased about 25 per cent. Barrels for packing, which formerly sold for 12.5 rupees, now cost 25, and the increased cost of explosives is large. It is therefore evident that but little profit is left to the miners at the present average price. It is stated that one of the largest mines will not be reopened until the price for best-quality plumbago reaches 60 rupees per ton. With the tendency which has been manifest for some months past of exchange to again approach normal, it may be that this price will soon be reached.

"It is estimated that the amount of plumbago available in the Colombo market on Jan. 1. 1920, was approximately 20,000 tons. The present available stocks have probably decreased to 17,000 tons.

"With the exception of three companies the mining operations are all in the hands of natives. There is no restriction against foreign companies owning mining properties or carrying on mining operations. The three companies above mentioned are British. The Ceylon Government assesses an *ad valorem* duty of 3 per cent. on all plumbago exported from the island."

The following excerpt from the report of the Inspector of Mines on 10 plumbago industries is of interest, and expresses a danger of the Ceylon product being displaced on the market.

"In former years Ceylon enjoyed practical monopoly of the world's supply of plumbago, but during the last 9 or 10 years it has lost this advantage, owing to plumbago having been discovered in large quantities in other countries, especially Madagascar, where the export has now reached something like 40,000 tons a year; and it is now a question whether Cyelon will be able to compete in the world's markets.

"Ceylon plumbago appears to possess superior qualities over that of other countries, but not sufficiently so to enable it to obtain very much higher prices, as the plumbago from other countries can be utilized for all practical purposes. To obtain a market the local articles will have to be placed at practically the same price as the foreign articles, and in order to do this it is feared that the Ceylon mine owners will have to be content with considerably less profits than they have enjoyed in the past, as the cost of production is always likely to be higher here than in Madagascar, owing to the fact that mines in Ceylon are deep, whereas those in Madagascar are mostly more or less surface ones.

"The cost of production, etc., is known only to those in the trade. It is to be hoped that every effort will be made to revive such an important industry, and to save it from expiring altogether. In previous years there have been slumps in the industry, due to temporary lack of demand for plumbago, but the present slump is an entirely different matter, as the demand for plumbago is as great or greater than it ever was, only, unfortunately for Ceylon, the supplies are being obtained from elsewhere. The position could not very well be worse than at present. The few mines working are producing more than the requirements, thereby adding to the existing large stocks."

Madagascar.—The French Ministry of the Colonies has just furnished the office of the Commercial Attaché at Paris information on the present production of graphite in Madagascar. It is stated business conditions ave been so unfavorable during 1920 that no new producing districts

have been opened, no new company for the exploitation of graphite has been formed, and operations at a number of the old deposits have ceased. This is explained by the fact that adverse conditions have recently necessitated selling graphite at a loss. Resumption of operations at the old beds is dependent only upon more favorable conditions, and new deposits will doubtless be discovered as soon as there is some incentive to greater production.[1]

U. S. Consul James G. Carter furnishes the following review of the Madagascar graphite industry in recent years:[2]

"The record year for the production of graphite in Madagascar was 1917, when 35,000 metric tons was produced. The industry has not shown any substantial signs of improvement since the middle and latter part of 1918 when the British and the French markets ceased partaking of the monopoly of the Madagascar graphite enjoyed by them throughout the war, and when the United States market ceased buying the Ceylon graphite and showed no desire to take over the Madagascar product, then anxiously offered.

"Below are given the official figures of the production and exportation of graphite in Madagascar from the beginning of the industry, in 1907, to 1920, inclusive, the 1919 and 1920 exports representing chiefly old stocks.

PRODUCTION AND EXPORTS OF GRAPHITE IN MADAGASCAR
(In metric tons)

	Production.	Exports.		Production.	Exports.
1907	8	8	1914	11,232	7,940
1908	82	109	1915	15,940	12,189
1909	197	200	1916	26,254	26,209
1910	545	554	1917	35,000	27,838
1911	1,247	1,281	1918	16,000	15,015
1912	5,318	2,638	1919	5,000	4,050
1913	7,227	6,573	1920	(a)	14,919

(a) 4000 to 5000 tons.

"The exports are given as having been slightly in excess of the production during the years 1908 to 1911. These differences are due to the fact of the production being given in net weight and the exports in gross weight. The above figures for exports are taken from customs returns.

"According to a published statement of the Chief of Madagascar Service of Mines, based upon an investigation made by the local Government, the quantity of graphite in stock in Madagascar on Apr. 1, 1920, amounted to 32,000 tons. The quantity exported during the period Apr. 1 to Dec. 31, 1920, was 11,031 tons, leaving 20,369 tons, to which should be added the estimated production of 4000 to 5000 tons in 1920,

[1] *Comm. Rept.*, Feb. 5, 1921.
[2] *Comm. Rept.*, Apr. 19, 1921.

giving an estimated stock of 24,000 to 25,000 tons at the end of 1920. No precise data are available as to the quantity of the different grades of graphite on hand, but approximately nine-tenths of the stock is flake graphite, the remaining being amorphous. Three-fourths of the flake graphite averages 80 to 90 per cent. carbon, particularly of the old stock, the tendency now being to turn out an average quality of 90 per cent. and above because of the restricted demand for this article.

"Of the 14,919 tons of graphite exported from Madagascar in 1920, 3288 tons was shipped in the first quarter, 3070 tons in the second quarter, 5307 tons in the third quarter, and 3254 tons in the last quarter. Of the total shipments in 1920, 4449 tons went to England, 2127 tons to the United States, and the remainder to France, with the exception of 50 tons shipped to Belgium. Shipments have again been reduced, and the only information to be had concerning the present demand is regarding a contract held by one of the large mining concerns for 2000 tons to be delivered in the present year to France.

"The prices obtained for the graphite shipped in 1920 averaged 600 to 700 francs per ton f.o.b. Tamatave and Vatomandry for material averaging 85 to 90 per cent. carbon. These are the prices at which quantities of Madagascar flake may now be had, and the freight on this material from Madagascar to New York, London, Hamburg, and other European, excluding French, ports, is now quoted by one French line at 300 francs, and by another at £7 sterling, while the rate to Marseille is 200 francs by both lines. The Madagascar flake, however, can be profitably produced at a cost low enough to support an f.o.b. price of 500 francs per ton.

WORLD'S PRODUCTION OF GRAPHITE
(In metric tons)

Year.	Austria.	Bavaria.	Canada. (c)	Ceylon. (a)	India.	Italy.	Japan.	Mexico. (b)	Sweden.	United States. (c)	France and Colonies.
1904	28,620	3,784	410	26,478	2,955	9,765	216	970	55	2,045	.....
1905	34,416	4,921	491	31,134	2,361	10,572	209	970	40	1,933	.....
1906	38,117	4,055	405	36,578	2,642	10,805	177	3,915	37	2,220	.....
1907	49,425	4,033	525	33,027	2,472	10,989	103	3,202	33	2,080	.....
1908	44,425	4,844	227	26,227	2,919	12,914	177	1,076	66	1,557	300
1909	40,710	(e)4,900	783	25,995	3,182	11,583	284	1,704	26	5,875	320
1910	33,131	7,415	1,263	30,008	4,319	12,510	145	2,332	49	3,811	1,100
1911	41,599	11,298	1,154	27,433	4,047	12,621	114	2,974	65	3,280	1,870
1912	45,375	12,532	1,873	33,106	*Nil.*	13,170	149	2,865	79	3,318	5,600
1913	49,456	12,032	1,961	29,277	*Nil.*	11,145	665	1,057	88	4,331	(d)7,227
1914	.....	.....	1,494	14,451	*Nil.*	8,567	574	3,864	56	3,935	(d)7,749
1915	.....	.....	2,368	22,159	71	6,176	666	1,524	87	4,280	(d)11,851
1916	.....	.....	3,589	33,947	1,341	8,182	1,144	4,836	194	7,339	(d)25,480
1917	.....	.....	3,369	27,482	105	12,117	1,329	6,868	123	12,331	(d)35,000
1918	.....	.....	2,768	15,702	82	11,653	.....	5,080	.....	11,785	(d)16,000
1919	.....	.....	1,234	6,778	729	7,626	.....	.....	.....	6,733	(d)5,000
1920	.....	.....	2,020	.....	.....	4,190	.....	.....	.....	8,627	(d)4,500

(a) The figures for 1907, 1908, and 1912 to 1919 are exports. (b) Exports. (c) Crystalline graphite up to 1909. Does not include artificial graphite. (d) Madagascar. (e) Estimated.

"It is estimated that about 20 per cent. of the total production of Madagascar graphite is treated mechanically. There are perhaps not more than a half-dozen plants equipped with machinery, which consists chiefly of drying, separating, classifying, ventilating, and screening devices, kept more or less secret."

Western Australia.—An English company has been reported as making preparations for the working of very extensive graphite deposits in that State.

American Clay in Graphite Crucibles

The manufacture of graphite crucibles requires as careful attention to the character of the clay as to the kind of graphite and it is therefore of interest to know that the clay problem seems to have been satisfactorily solved, as related by Dorsey A. Lyon in the following brief report published by the U. S. Bureau of Mines.

Prior to 1914 practically all graphite crucibles manufactured in the United States were made from Ceylon graphite bonded with German Klingenberg clay. It was the general belief among graphite crucible manufacturers and users that good crucibles could not be made from American bond clays and graphites. Graphite crucibles were essential for melting certain alloys and special steels urgently needed for the manufacture of war materials. The demand for such metals was so great that it created an unprecedented demand for graphite crucibles.

After the Great War began no Klingenberg clay could be shipped out of Germany. However, it was fortunate for the crucible makers that they had large stocks of Klingenberg clay on hand. When the stock of Klingenberg clay became exhausted it was necessary for the crucible makers to turn their attention to American clays. There were no data or other information available to guide the crucible makers in the selection of good bond clays for their crucibles. It was necessary for them to select their clays by "guess," which resulted in the period of service or life of graphite cucibles being shortened 15 to as much as 60 per cent.

The ceramic station at Columbus, Ohio, undertook the investigation of American bond clays and graphites to determine their crucible-making properties as compared with foreign raw materials, and to furnish both crucible makers and users with much-needed information. Careful laboratory tests were made on a large number of clays. As a result of these tests the clays were "sifted down" to twenty which appeared to be promising. Eighteen of these clays were domestic, one was an English clay, and one the German Klingenberg clay.

After the laboratory tests were completed, the next step was to apply the results obtained in the laboratory to actual factory practice. Fifteen large-size crucibles were made of each of the twenty clays, using a standard graphite. That the tests might be comparable to actual practice, the crucibles were made in the regular manner at the plant of the Vesuvius Crucible Co., Swissvale, Pa. Ten of the crucibles of each clay were tested under the regular foundry practice for melting brass at the plant of the Detroit Lubricator Co., Detroit, Mich., and five were tested under steel-melting practice at the foundry of the Simonds Manufacturing Co., Lockport, N. Y. Three representatives of the ceramic experiment station were present during the tests and kept accurate records of the performances of the crucibles. The results

of the tests on the brass-melting crucibles showed that two American clays tested higher than the German Klingenberg clay and eight tested higher than the English clay. Tests on the steel-melting crucibles showed thirteen domestic clays giving crucibles of higher service than the Klingenberg clay and five testing higher than the English clay.

At present 120 crucibles are being made to test the crucible-making properties of the foreign and domestic graphites. Graphite samples are to be tested from the following localities: Ceylon, Madagascar, Canada, New York, Alabama, Texas, and Montana. The work on the bond clays is finished and the tests on the graphites will be completed soon. The crucible makers of the United States have been quick to profit by these experiments. In so far as has been determined, no German Klingenberg clay is used in America at present, and it is gratifying to note that some crucible makers advertise that the superior qualities of their crucibles are due to the use of the best American bond clays.

Recent Important Publications on Graphite

Dub, George D. and Moses, Frederick G.—Mining and Preparing Domestic Graphite for Crucible Use. 80 pp., 5 plates, 20 figures. Bulletin 112, U. S. Bureau of Mines, Washington, 1920.

Contains descriptions of mining and milling methods used in Alabama, New York, Pennsylvania, and Texas, and also the results of experiments by the Bureau of Mines.

Redfield, Arthur H.—Foreign Graphite in 1919. *Min. Res. of the U. S.*, 1919, Part II, pp. 181–210, U. S. Geol. Surv., Washington, 1921.

A summary of the graphite deposits of the world, illustrated with maps showing locations of the important districts.

Spence, Hugh S.—Graphite. 202 pp., 56 plates, 43 figures. Mines Branch, Department of Mines, Canada, Ottawa, 1920.

The report replaces the excellent monograph of Cirkel published under the same auspices in 1907 and now out of print. In addition to detailed descriptions of the Canadian deposits it contains valuable discussions of the graphite deposits of other countries, uses of graphite, concentrating and refining processes, origin, history, methods of analysis of graphite ores, etc.

U. S. Tariff Commission.—Information Concerning Graphite. 28 pages, Washington, 1919.

A brief summary of the uses, distribution, and economic features of the world's graphite industry.

Wilson, M. E.—Geology and Mineral Deposits of a Part of Amherst Township, Quebec. 54 pp., 7 plates, 3 figures. Memoir 113, Geological Survey, Department of Mines, Canada. Ottawa, 1919.

Contains a brief description of graphite deposits.

————.—Mineral Deposits in the Ottawa Valley. *Summ. Rept.*, 1919, Part E, pp. 19–44, Geological Survey, Department of Mines, Canada, Ottawa, 1920.

Contains a geologic map and geologic description of the Black Donald Graphite Co.'s property, the most important deposit in Canada from the standpoint of production.

GYPSUM

By Frank A. Wilder

Gypsum mined in the United States in 1920 totaled 3,130,305 short tons. The highest previous record was in 1916 ,when the mine output reached 2,757,730 tons. The gain, therefore, over any previous year was considerable. Compared with 1919 the increase was more than 700,000 tons. All the more important producing states showed gains in output. Gains were general for all forms of gypsum products. The output of agricultural gypsum increased about 270 per cent. over the preceding year.

CRUDE GYPSUM MINED IN THE UNITED STATES (a)

State.	1917. Quantity Mined (Short Tons).	1918. Quantity Mined (Short Tons).	1919. Quantity Mined (Short Tons).	1920. Quantity Mined (Short Tons).
Iowa	461,864	327,927	421,279	571,895
Kansas	79,331	54,958	78,479	130,044
Michigan	375,803	286,768	339,125	382,212
New York	606,268	531,038	591,153	780,295
Ohio	270,538	199,456	251,259	277,899
Oklahoma	158,017	126,208	114,313	135,279
Texas	257,328	157,388	176,607	220,157
Wyoming	55,844	41,877	51,079	57,732
Nevada	(c)	(c)	91,756	143,929
Other States	(b)431,223	331,395	305,113	430,963
	2,696,226	2,057,015	2,420,163	3,130,305

(a) R. W. Stone, U. S. Geol. Surv. (b) Includes Arizona, California, Colorado, Montana, New Mexico, Oregon, South Dakota, Utah, Virginia. (c) Included with "Other States."

CRUDE GYPSUM MINED IN THE UNITED STATES (a)
(Tons of 2000 lb.)

1885	90,405	1897	288,982	1909	2,252,785
1886	95,250	1898	291,638	1910	2,379,057
1887	95,000	1899	486,235	1911	2,323,970
1888	110,000	1900	594,462	1912	2,500,757
1889	267,769	1901	633,791	1913	2,599,506
1890	182,995	1902	816,478	1914	2,476,465
1891	208,126	1903	1,041,704	1915	2,447,611
1892	256,259	1904	940,917	1916	2,756,630
1893	253,615	1905	1,043,202	1917	2,696,226
1894	239,312	1906	1,540,585	1918	2,057,015
1895	265,503	1907	1,751,748	1919	2,420,163
1896	224,254	1908	1,721,829	1920	3,130,305

(a) Statistics of the U. S. Geol. Surv.

TOTAL VALUE OF CRUDE AND CALCINED GYPSUM

1908	$4,075,824	1913	$6,774,822	1918	$11,470,854
1909	5,906,738	1914	6,895,989	1919	15,727,907
1910	6,523,029	1915	6,596,893	1920	24,542,512
1911	6,462,035	1916	7,959,032		
1912	6,563,908	1917	11,116,452		

Named in the order of tonnage produced the leading states rank as follows: New York, Iowa, Michigan, Ohio, Texas, Virginia, Nevada, Oklahoma, Kansas. The same order will hold for values, with the possibility that Virginia and Texas might exchange places. Virginia's position is not set out by itself in the federal statistics in view of the fact that there are only two producers in the State. The output of each of these plants is considerably above that of the average, taking the gypsum mills of the country as a whole.

	Total Value of Gypsum Products, 1920.
Iowa	$4,422,965
Kansas	968,298
Michigan	3,521,028
Nevada	1,100,261
New York	6,438,929
Ohio	2,161,038
Oklahoma	816,768
Texas	1,439,491
Wyoming	410,734
Other states	3,263,010
	$24,542,512

The large tonnage and high value of gypsum and gypsum products for 1920 were the result of several factors. Most important was the building activity during the year. This stimulated the output of gypsum for use in Portland cement, and for gypsum calcined for plaster and wall-boards. Construction work which had been repressed during the war was again well under way by the middle of 1919, and so far as the use of gypsum was concerned reached its peak in July of 1920. The depression which began to manifest itself in many lines earlier in the year did not affect the gypsum industry until November, and the business handled before that month was sufficient to make the year by all odds the best that the gypsum mills have enjoyed.

Factors which in themselves gave only a small part of the total increase in tonnage, but which are of great significance when the future of the industry is considered, were the increases in output of agricultural gypsum and of wall- and plaster-board. Agricultural gypsum increased from 39,978 tons in 1919 to 107,443 tons in 1920. During the 10 years prior to 1920 a very large part of the agricultural gypsum sold was used on the peanut crop in two or three of the southeastern states. During 1920, however, considerable quantities of agricultural gypsum were used on alfalfa in the northwest with highly satisfactory results. Smaller quantities were used on various crops, but particularly on legumes, in many states and these experimental patches promise to serve as nuclei for the spread of gypsum as a fertilizer. Reimer's bulletin issued in July, 1919, by the Oregon Experiment Station, on "Sulphur as a Fertilizer for Alfalfa," attracted the attention of students of plant nutrition throughout the country and its effect was felt during 1920. The literature on the

GYPSUM PRODUCED AND MARKETED IN THE UNITED STATES[1]

Year.	Sold Without Calcining.											
	For Portland Cement.			As Land Plaster.			For Other Purposes.			Total.		
	Quantity, Short Tons.	Value.	Average Price per Ton.	Quantity, Short Tons.	Value.	Average Price per Ton.	Quantity, Short Tons.	Value.	Average Price per Ton.	Quantity, Short Tons.	Value.	Average Price per Ton
1915	(a)406,393	(a) 528,161	$1.30	69,256	$122,714	$1.77	.....	.....	.....	475,649	$650,875	$1.37
1916	(a)454,112	(a) 607,995	1.34	81,879	167,136	2.04	11,128	$15,299	$1.37	547,119	790,430	1.44
1917	(a)526,881	(a) 867,123	1.65	84,366	230,808	2.74	12,748	26,439	2.07	623,995	1,124,370	1.80
1918	(a)403,635	(a) 974,283	2.41	64,572	255,716	3.96	1,986	6,553	3.30	470,192	1,236,552	2.63
1919	(a)470,267	(a)1,232,637	2.83	39,978	185,566	4.64	(a)	(a)	.....	510,245	1,518,203	2.98
1920	(a)541,901	(a)1,941,057	3.58	107,443	557,925	5.19	19,916	66,213	3.32	669,260	2,565,195	3.83

Year	Sold Calcined.														
	As Plaster of Paris, Wall Plaster, Keene's Cement, etc.			For Dental Plaster.			To Glass Factories.			As Boards, Tile, and Blocks, and for Other Purposes.			Total.		
	Quantity, Short Tons.	Value.	Average Price per Ton.	Quantity, Short Tons.	Value.	Average Price per Ton.	Quantity, Short Tons.	Value.	Average Price per Ton.	Quantity, Short Tons.	Value.	Average Price per Ton.	Quantity, Short Tons.	Value.	Average Price per Ton.
1915	1,520,308	$5,776,826	$3.80	534	$2,376	$4.45	11,861	$26,620	$2.25	81,017	$140,196	$1.73	1,613,720	$5,946,018	$3.68
1916	1,677,081	6,884,960	4.11	661	8,766	13.26	11,537	28,839	2.50	116,535	246,037	2.11	1,805,814	7,168,602	3.97
1917	1,531,535	8,873,176	5.79	991	7,672	7.74	13,808	72,558	5.25	131,056	1,038,676	7.93	1,677,390	9,992,082	5.96
1918	1,174,359	8,483,633	7.22	(b)	(b)	.....	13,567	84,928	6.26	b)140,343	1,665,741	11.88	1,328,269	10,234,302	7.70
1919	1,393,141	11,809,624	8.48	(b)	(b)	.....	14,677	96,561	6.58	b)188,202	2,303,519	12.24	1,596,020	14,209,704	8.90
1920	1,578,360	15,723,372	9.96	1,731	27,440	15.85	15,637	125,441	8.02	308,756	6,091,617	19.73	1,904,484	21,967,870	11.53

[1] R. W. Stone, U. S. Geol. Surv.
(a) A small quantity of paint material included with gypsum sold for Portland cement.
(b) Some dental plaster included with boards, tile, etc.

subject of sulphur fertilization during 1920 was important and voluminous. A few of the more important titles appear in the bibliography attached to this article.

A similar increase in the amount of gypsum used for making boards tile and blocks, appear in the figures shown in the table on page 342, There has been a consistent increase in the amount of gypsum used for these purposes during recent years. The increase of 120,000 tons for 1920 over 1919 means a gain of about 75 per cent. over the previous high mark.

New York (By D. H. Newland).—The gypsum industry was very active last year, and production reached a record level. Prices of most gypsum materials were higher than in 1919, but the rise was not out of proportion to the increased costs of fuel, labor, and other items that the plants had to meet. In fact conditions were probably less prosperous than one might infer from mere consideration of the statistical record; moreover, the middle of the year witnessed a shading off of the brisk demand, followed by a decided reaction that gained headway with each successive month. At the end the industry was facing an uncertain outlook, to express the situation mildly, with every indication of a protracted period of slackening market conditions.

Preliminary figures of production are given in the accompanying table, together with the completed totals for 1919 as published by the U. S. Geological Survey. The estimate of 780,295 tons for mined rock represents a gain of 32 per cent. over the previous year's total and exceeds by fully 25 per cent. the maximum reached by the industry up to the time. A total of 271,077 tons was marketed in uncalcined condition, principally to cement plants. The manufactured articles of calcined gypsum amounted to 387,856 tons. The aggregate value of the gypsum and its products, $6,438,929, is not far behind the largest total reported for annual sales throughout the country up to 5 years ago.

PRODUCTION OF GYPSUM IN NEW YORK(a)

Material.	1918.		1919.		1920.	
	Short Tons.	Value.	Short Tons.	Value.	Short Tons.	Value.
Output, crude	531,038	.....	591,153	.....	780,295	.....
Sold, uncalcined	179,968	$442,087	216,417	$620,339	271,077	$987,503
Sold, manufactured forms	278,472	2,213,460	316,767	2,910,404	387,856	5,451,426

(a) U. S. Geol. Surv. and N. Y. State Geol. Surv.

Field-work received a good deal of attention, both from the established enterprises and from interests not already represented in the local

industry. The known supplies of gypsum in the Erie and Genessee County districts, which contain the best grade of rock, are not over-large, and, with a 4 to 5-ft. bed that constitutes the overage deposit for that region, a considerable acreage of new ground must be brought in each year to keep pace with the progress of mining. Although the deposits lie nearly flat and are shallow, they are of uncertain continuity, especially in the direction of the dip. Core-drilling is the common method of exploration. If recent results may be taken as a guide, it would appear that the areas of gypsum occurrence are rather restricted and between them may be found long intervals that are destitute of workable beds.

The Phoenix Gypsum Co. completed a shaft on its property at South Alabama (Wheatville Station), which adjoins the Niagara Gypsum Co.'s lands on the west. The mine has not as yet entered upon regular production. The American Hard Wall Plaster Co. was engaged in developing a property to the south of the Niagara mines. By these and other developments the Oakfield gypsum district has been extended for a mile or more to the west.

At Akron the American Gypsum Co. and the American Cement Plaster Co. carried out exploration in territory adjacent to their holdings, but otherwise no developments were recorded in this district.

The Ralph Gypsum Co. secured leases and began exploration of several farms near South Byron, Genessee County, about midway between Oakfield and the Wheatland-Garbutt district. Gypsum was quarried here on a small scale at one time, but the extent and character of the deposits were hardly disclosed by the operations. It is not likely that any production will be made here during the current year.

Gypsum was discovered by drilling some years ago at Victor, southeast of Rochester. Further tests were made last summer, and plans have been under consideration for opening the deposit by a shaft with a view to the supply of cement rock. The grade of gypsum is about like that at Garbutt. The depth to the main bed is a little over 100 ft.

Texas (By D. H. Newland).—Gypsum wall-plasters are made in three mills, all of which employ gypsite. One of the plants (Acme) combines its gypsite operations with the mining of gypsum rock which occurs below the bed of gypsite and uses the rock for Keene's cement and blocks. While gypsite makes good wall-plasters that are especially adapted for the Southern trade, it does not lend itself so readily to the manufacture of fabricated materials like board and blocks, for which regularity of set is an important feature.

The Texas Cement Plaster Co. enlarged and improved its plant at Plastico, 5 miles southwest of Hamlin. The deposits of gypsite are so regular and continuous that they are worked by steam-shovel operating

within the pit and loading directly into cars which run over a track laid in the pit to the mill. Elsewhere in Texas the beds are rarely large enough to admit of this method. Wheel-scrapers drawn by horses or tractors are usually employed and their loads are dumped through a trap into cars which run on surface tracks or into motor-trucks, and so to the mill. The conditions are a severe test for tractors, on account of the soft ground and generally dusty surroundings which make for rapid wear. The caterpillar type seems best adapted to the work.

The U. S. Gypsum Co. purchased a mine and mill site near Sweetwater, embracing about 200 acres 3 miles east of the town at the junction of the Santa Fe and Texas & Pacific railroads. Reports are current that a large plant will be erected, although no steps to that end were taken last year. The lands are underlain by several beds of rock gypsum, the main one averaging 8-10 ft. thick and containing high-grade material, white in color. Underground mining will be necessary as the cover is too heavy for stripping.

Canada.[1]—Gypsum production exhibited a substantial gain in 1920, the value of the shipments of crude, crushed or calcined product being greater than in any previous year and the tonnage the highest since 1915. The total quantity of gypsum rock quarried in 1920 was 460,354 short tons, of which 148,964 tons was calcined. The shipments of all grades totaled 429,144 tons valued at $1,876,595 and included: lump gypsum, 262,442 tons valued at $439,762; crushed, 48,378 tons valued at $146,947; fine ground, 6615 tons valued at $146,584; and calcined, 111,708 tons valued at $1,243,302.

By provinces the shipments were: Nova Scotia, 260,661 tons valued of $556,356; New Brunswick, 49,405 tons valued at $428,183; Ontario, 74,707 tons valued at $404,162; and Manitoba, 45,371 tons valued at $487,894.

In 1919 the quantity of gypsum rock quarried was 303,998 tons, of which 121,496 tons was calcined. The shipments included: lump, 172,781 tons valued at $206,858; crushed, 27,939 tons valued at $68,002; fine ground, 3,842 tons valued at $18,901; calcined, 94,501 tons valued at $921,526; or a total of 299,063 tons valued at $1,215,287.

The exports of crude gypsum in 1920 were 244,428 tons valued at $413,522, and ground gypsum, plaster of Paris, etc., valued at $232,736. The corresponding exports in 1919 were: crude gypsum, 148,394 tons valued at $199,857, and ground gypsum, etc., valued at $140,235.

The imports of gypsum of all grades during 1920 were 5234 tons valued at $78,302, and included: crude gypsum 2294 tons valued at $25,477; ground gypsum, etc., 118 tons valued at $3966, and plaster of

[1] Prelim. Rept. Min. Prod. of Canada, 1920. Can. Dept. of Mines.

Paris 2822 tons valued at $48,859. The imports in 1919 totaled 2848 tons valued at $47,455.

PRODUCTION OF CRUDE GYPSUM IN THE PRINCIPAL COUNTRIES (a)
(In metric tons)

Year.	Algeria. (b)	Canada. (g)	France. (b)	Germany. (c)		Greece.	India.	United Kingdom.	United States.
				Baden.	Bavaria.				
1903.....	41,550	285,242	1,998,804	29,423	30,894	94	(d)	223,426	945,286
1904.....	48,375	309,133	1,957,802	26,984	22,766	393	3,937	237,749	853,546
1905.....	34,743	395,341	1,378,145	28,823	46,247	185	4,877	259,596	982,625
1906.....	27,950	378,904	1,377,429	25,643	50,763	70	(e) 5,000	228,627	1,397,480
1907.....	26,400	431,286	1,316,567	29,153	48,975	70	(e) 5,000	239,285	1,564,061
1908.....	25,500	346,436	1,750,562	35,217	51,314	Nil.	(e) 5,000	231,980	1,694,155
1909.....	36,250	398,290	1,655,672	36,621	51,630	191	17,588	242,832	(f)2,042,286
1910.....	60,625	481,941	1,980,804	41,078	54,397	249	13,759	259,648	(f)2,158,756
1911.....	61,502	470,381	2,110,520	42,408	60,390	1,263	11,115	281,111	(f)2,112,770
1912.....	54,414	524,892	2,150,900	51,777	57,114	127	21,383	247,724	(f)2,269,290
1913	50,413	577,442	1,726,379	49,767	.....	2,245	25,362	242,341	(f)2,357,752
1914	.....	463,375	.....	.....	32,993	639	22,639	269,637	(f)2,247,246
1915	.....	430,752	.....	.....	28,459	1,648	22,926	251,209	(f)2,220,458
1916	.....	311,092	.....	.....	26,124	356	16,826	222,814	(f)2,500,815
1917	.....	305,120	.....	.....	21,035	44	16,952	175,800	(f)2,446,016
1918.....	.....	138,155	.....	.....	23,330	.....	17,016	181,612	(f)1,865,622
1919.....	.....	278,454	.....	.....	33,692	.....	28,774	223,545	(f)2,223,547
1920.....	.....	389,319	.....	.....	.....	.....	.....	291,598	(f)2,838,758

(a) From official reports of the respective countries, except the statistics for the United States. (b) A part of the product is reported as plaster of Paris. In converting this into crude gypsum it has been assumed that the loss by calcination is 20 per cent. (c) Prussia is a large producer of gypsum, but there are no complete statistics available. The output in 1910 was 22,042 tons. (d) Statistics not available. (e) Estimated. (f) U. S. Geol. Surv. (g) Tonnage shipped. See detailed statement on Canada for total tonnage produced.

Imports and Exports.—The imports of gypsum increased in 1920, but are not so large as before the war. The imports of crude and calcined gypsum in 1920 amounted to 279,407 short tons, as compared with 154,925 tons in 1913.

Export figures for 1920 are not available, but when published they will probably show larger figures than for preceding years. There has been a steady and rapid increase in the amount of gypsum plaster and wall-board exported, the gain in value going from $108,505.00 in 1916 to $1,141,815.00 in 1919. England, Japan and Canada were the largest purchasers in 1919. New York exported gypsum products valued at nearly half a million dollars. Gypsum exports moving across the Pacific were for the most part shipped from ports in Washington.

Mine and Mill Development During the Year

According to trade papers the Rock Plaster Mfg. Co. of New York and the Nova Scotia Gypsum Corporation of Manhattan consolidated during 1920, under the name of the Rock Plaster Corporation.

The Ralph Gypsum Co., LeRoy, N. Y., has purchased about 3000 acres of mineral land 4 miles from LeRoy, is sinking a shaft and is contemplating the erection of a mill.

The Connecticut Adamant Plaster Co., New Haven, Conn., whose plant was destroyed by fire in July, 1920, is rebuilding of concrete and steel.

The Ebsary company at Wheatland is building a new fireproof calcining plant.

The American Hard Wall Plaster Co. of Utica has sunk a shaft about three miles from Oakfield.

The Phoenix Gypsum Co., Wheatville, N. Y., has sunk a shaft and erected a crushing plant for supplying crushed gypsum.

The Iowana Gypsum Co., Fort Dodge, Iowa, has completed its mill. Its equipment is said to include some novel and interesting features. This company is closely affiliated with the Plymouth Gypsum Co. of Fort Dodge.

The Colorado Portland Cement Co., Denver, with gypsum mill at Gypsum, Colo., has increased the capacity of its calcining plant.

The Laramie Cement Plaster Co. is constructing a mill at Laramie. Two companies, the Overland and the Acme, are already operating mills in that field.

The mill of the Globe Plaster Co. at Carlsbad, N. Mex., burned in the spring of 1920, and was rebuilt, enlarged and again placed in operation during the summer of the same year.

The White Star Plaster Co., Moapa, Nev., was a producer during 1920. Gypsite is used as raw material.

The United States Gypsum Co. is reported to have purchased extensive gypsite beds near Sweetwater, Tex., and to contemplate the erection of a large plant to that point. The same company is reported as strengthening its organization in California, relying on its gypsum properties at Arden, Nevada, and Amboy, Calif. for an increased supply of gypsum products.

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IRON AND STEEL

By Edwin F. Cone

The feature of the American steel industry in the year 1920 was the size of the output of both pig iron and steel. The steel output was exceeded only in the years 1916, 1917 and 1918, and besides this there were several special features. Among these were the electric-steel output, which was the country's second largest, and not far from that of 1918, or 502,152 gross tons compared with 511, 364 tons. This is also true of the total of alloy-steel ingots and castings.

One rather serious strike handicapped this industry in 1920, that of the railroad switch men in April, which resulted in a blockade which crippled many steel plants for a long time. There was also a fuel scarcity, as a direct result, which caused the banking of many blast-furnaces.

Prosperity was dominant the greater part of the year, or until October. In the early months steel prices advanced steadily. By the middle of the year there was a gradual letting down until the third quarter, when cancellations of orders followed one on another. By the end of December independent steel companies, which had enjoyed a price range for their products way above that of the Steel Corporation, reduced them to a level with the leading interests.

As the year drew to a close, there were decided signs of an approaching depression. The Steel Corporation was well booked ahead, but the independent companies were short of orders, having conducted their business on a prompt-delivery basis. By December the Steel Corporation was operating at about 85 per cent. of capacity, while the independents were doing not much better than half as much as the leading interests.

Imports and Exports.—The imports and exports of iron and steel are tabulated below. Exports were heavier in 1920 than in 1919 on most products. The total for 1920 was 4,961,851 gross tons against 4,239,837 tons in 1919 and 5,338,037 tons in 1918.

UNITED STATES EXPORTS OF DOMESTIC IRON AND STEEL
(In tons of 2240 lb.)

	1913.	1914.	1915.	1916.	1917.	1918.	1919.	1920.
Pig iron	277,648	114,423	224,509	612,241	656,220	269,575	321,261	216,828
Billets, blooms, etc.	91,847	50,496	560,704	1,504,562	2,017,113	1,786,289	258,424	216,873
Bars steel	228,331	128,228	465,720	848,479	682,798	642,516	554,211	624,587
Rails	460,553	174,680	391,379	540,349	512,669	453,944	652,449	594,634
Sheets and plates	463,414	280,090	419,637	515,462	831,736	824,886	1,029,011	1,141,371
Structural steel	403,264	182,395	232,139	300,594	294,150	232,729	360,787	493,655
Wire	190,282	180,395	473,583	683,025	393,825	392,305	291,662	325,142
Wire-rods	61,636	61,853	165,014	158,284	181,975	148,523	118,009	116,775
Nails and spikes	62,726	49,622	118,349	191,131	159,978	104,311	129,233	122,606
Pipe and fittings	301,784	199,618	176,884	228,573	209,184	145,943	275,535	353,590

Total imports in 1920 were 417,581 long tons, which compare with 322,261 tons in 1919 and with 179,702 tons in 1918. The 1920 total was the largest in any year from 1913 to 1920.

UNITED STATES IMPORTS OF IRON AND STEEL
(In tons of 2240 lb.)

	1912.	1913.	1914.	1915.	1916.	1917.	1918.	1919.	1920.
Pig iron	129,325	165,450	138,903	89,836	135,349	76,786	34,711	101,665	196,364
Billets, blooms, etc.	18,702	26,675	49,188	14,998	26,142	44,195	41,072	16,268	26,022
Scrap iron and steel	23,612	44,154	34,849	79,982	116,039	180,034	63,730	177,293	140,645
Bars, iron	26,112	28,243	15,015	8,474	7,701	2,240	1,469	1,940	4,987
Rails	3,780	10,408	22,571	78,525	26,299	9,263	8,705	17,008	45,684
Wire-rods	15,070	16,097	6,954	5,316	4,130	1,006	7,677	342	5,847
Tinplate	2,052	20,680	15,411	2,350	1,007	124	32	242	400

Iron Ore

The iron-ore output of the United States in 1920 was 67,773,000 gross tons, against 60,466,000 tons in 1919 and 69,658,278 tons in 1918, according to the figures compiled by Ernest F. Burchard of the United States Geological Survey. This represents an increase of about 11 per cent.

The shipments of ore from the mines in 1920 are estimated at 69,558,000 gross tons, valued at $290,607,000, an increase in quantity of nearly 24 per cent. and in value of nearly 43 per cent. as compared with 1919. The average selling value of the ore per gross ton at the mines for the United States in 1920 was $4.18; in 1919 it was $3.61. The stocks of iron ore at the mines, mainly in Michigan and Minnesota, apparently decreased from 12,986,000 tons in 1919 to 11,145,000 tons in 1920, or 14 per cent.

The production of iron ore in 1920 was less than 2,000,000 tons below that of 1918 and is exceeded only by that of the war years 1916, 1917, and 1918. In 1920 shipments exceeded production by approximately 1,785,000 gross tons, but in 1919 production exceeded shipments by about 4,147,000 tons. These preliminary figures are based on returns from producers of nearly 97 per cent. of the normal output of iron ore and were supplemented by estimates covering the remainder of the output.

The Lake Superior district produced 86 per cent. of the iron ore mined and shipped in 1920. In this district a total of 58,173,000 gross tons was mined and 60,056,000 tons was shipped, increases of 12 and 24 per cent. respectively, as compared with 1919.

The ore shipped from the Lake Superior district in 1920 was valued at $257,543,000, an increase of about 43 per cent. The mines in Minnesota furnished 67 per cent. of the total iron ore shipped from the Lake Superior district and 58 per cent. of the total of the United States. The average

selling price of the ore at the mines in the Lake Superior district in 1920 was $4.29 a ton; in 1919 it was $3.70. The stocks of iron ore in this district apparently decreased fron 11,887,000 gross tons in 1919 to about 10,000,000 tons in 1920, or 16 per cent. The shipments of iron ore by boat from the Lake Superior district in 1920, according to figures compiled by the Lake Superior Iron Ore Association, amounted to 58,527,226 gross tons, a decrease of 24 per cent. as compared with 1919. The Southeastern States, which form the second-largest iron-ore producing area, including the Birmingham and Chattanooga districts, mined 6,663,000 gross tons of iron ore in 1920, a decrease of 16 per cent. as compared with 1919. The shipments of ore to blast-furnaces from these states in 1920 amounted to 6,575,000 gross tons, valued at $20,994,000, an increase in quantity of 18 per cent. and in value of nearly 32 per cent. as compared with the previous year. The average selling value of the ore in these states in 1920 was $3.19 a ton; in 1919 it was $2.87.

In the Northeastern States—New Jersey, New York and Pennsylvania— there was mined 2,027,000 gross tons of iron ore in 1920, an increase of 10 per cent., and there was shipped 2,070,000 gross tons, an increase of 27 per cent. The average selling value of the ore in these States was $4.93 a ton as against $4.06 in 1919.

IRON ORE MINED IN THE UNITED STATES IN GROSS TONS (a)

State.	1916.	1917.	1918.	1919.	1920.
Minnesota	44,585,422	44,595,232	41,953,969	35,767,000	39,964,000
Michigan	8,071,016	7,868,601	16,899,341	15,471,000	17,232,000
Alabama	6,747,901	7,037,707	5,754,624	5,034,000	5,850,000
Wisconsin	1,304,518	1,202,235	1,089,351	888,000	977,000
New York	1,342,507	1,30 ,317	906,179	858,000	927,000
Wyoming	545,774	543,846	447,884	.....	.....
New Jersey	493,004	489,943	423,525	409,000	420,000
Pennsylvania	559,431	546,700	522,600	547,000	680,000
Virginia	440,492	469,903	414,048	288,000	308,000
Tennessee	455,834	508,529	408,954	271,000	347,000
Georgia	256,949	226,630	264,602	80,000	89,000
North Carolina	64,306	90,997	108,332	67,000	69,000
Missouri	34,914	38,908	72,708	.....	.....
New Mexico	157,779	237,221	268,666	.....	.....
Colorado	*	*	7,850	.....	.....
Connecticut	*	*	12,130	.....	.....
Maryland	4,455	11,830	8,081	.....	.....
Nevada	9,910	1,010	20,303	.....	.....
Massachusetts	*	10,000	8,450	.....	.....
Ohio	1,800	.....	.....	.....	.....
California	3,000	2,207	3,107	.....	.....
Kentucky	.....	.....	.....	.....	.....
West Virginia	3,605	4,632	.....	.....	.....
Iowa	.....	22,612	7,052	.....	.....
Utah	.....	48,058	52,722	.....	.....
Arkansas	.....	40	.....	.....	.....
Other States	85,055	27,693	2,800	786,000	910,000
Totals	75,167,672	75,288,851	69,658,278	60,466,000	67,773,000

(a) U. S. Geol. Surv.
* Less than three producers in Colorado and Connecticut in 1917, Colorado, Connecticut and Massachusetts in 1916, and permission was not granted to publish state totals.

Lake Superior District.[1]—Lake shipments in 1920 totaled 58,527,226 tons, as compared with 47,177,395 tons in 1919, an increase of 11,349,831 tons. The total all-rail movement was 1,883,251 tons against 1,369,256 tons, a gain of 513,995 tons. The all-rail movement in 1920 was the largest since 1916, and only 54,851 tons less than the record all-rail movement in 1917. Following is the record of all-rail shipments since 1911:

1911	662,719	1916	1,924,268
1912	785,769	1917	1,938,102
1913	876,638	1918	1,679,440
1914	707,829	1919	1,369,256
1915	953,947	1920	1,883,251

The operations of the independent mining interests in the Lake Superior district may be gaged by comparison with those of the Oliver Iron Mining Co., subsidiary of the United States Steel Corp. This company's report shows that the latter shipped 24,936,073 tons in 1920, 41.28 per cent. of the total, as compared with 22,065,148 tons in 1919 or 45.20 per cent. of the total. In only two years since 1908 has the Oliver company exceeded 50 per cent. of the total, in 1909 showing 50.36 per cent. and in 1911, 52.70 per cent. Its percentage in 1920 was the lowest in 12 years. The highest it ever attained was in 1911, when it was 52.70. The average for the 12 years, 1909 to 1920 inclusive, is 46.50. On only two other occasions, in 1917 and 1918, has its annual shipment fallen below 45 per cent. of the total.

It was understood by the independent shippers that the Oliver company was behind in its shipments in 1920 and that it was making every effort to catch up. The close of the season found many furnaces supplied by the independent shippers with an excessive amount of ore on hand, with the furnaces facing a dull period. As if responsive to the situation, the shipments of the Oliver company slowed up to a greater extent, relatively speaking, than those of the other interests.

The following table shows the shipments and percentages of the Oliver Iron Mining Co., the Steel Corporation's mining organization, for each of the last 10 years:

Year.	Gross Tons.	Percentage.
1911	17,282,499	52.70
1912	23,845,363	49.46
1913	24,502,244	49.06
1914	16,039,654	49.01
1915	22,518,613	47.63
1916	31,673,131	47.52
1917	28,571,977	44.34
1918	26,178,782	41.66
1919	22,065,148	45.20
1920	24,936,073	41.28

[1] *Iron Tr. Rev.*, Feb. 17, 1921.

PRODUCTION OF IRON ORE IN LAKE SUPERIOR DISTRICT
(In tons of 2240 lb.)

Year.	Tonnage.	Year.	Tonnage.	Year.	Tonnage.	Year.	Tonnage.	Year.	Tonnage.
1855...	1,449	1880..	1,948,334	1905..	34,353,456	1914..	33,629,613	1919..	47,177,395
1860...	114,401	1885..	2,466,642	1910..	43,442,397	1915..	46,994,254	1920..	58,527,226
1865...	193,758	1890..	9,003,725	1911..	32,793,120	1916..	64,734,198	.....	.....
1870...	859,507	1895..	10,429,037	1912..	46,483,798	1917..	62,498,901	.....	.....
1875...	881,166	1900..	19,059,393	1913..	52,518,158	1918..	61,156,732	.....	.....

SHIPMENTS OF IRON ORE FROM LAKE SUPERIOR DISTRICTS
(In tons of 2240 lb.)

Range.	1915.	1916.	1917.	1918.	1919.	1920.
Marquette.....	4,105,378	5,396,007	4,874,150	4,354,297	2,992,212	4,608,323
Menominee.....	4,982,626	6,364,363	6,045,750	6,378,698	4,442,868	6,562,106
Gogebic.....	5,477,767	8,489,685	7,981,684	7,936,701	6,230,839	8,763,332
Vermillion.....	1,733,595	1,947,200	1,530,692	1,192,908	929,049	1,007,435
Mesabi.....	29,756,689	42,525,612	41,445,211	40,396,711	31,997,699	37,149,277
Baraboo.....	80,583	1,716,218	136,632	98,057	92,819	129,571
Cuyuna.....	1,136,113	219,381	2,422,884	2,478,000	1,861,165	2,190,433
Total.....	47,272,751	66,658,466	64,437,003	62,836,172	48,546,651	60,410,477

Shipments from the Mesabi range in 1920 amounted to 37,149,277 tons or 5,151,578 more than in 1919. The total last year was 61.33 per cent. of all shipments from the Lake Superior district. The percentage in 1919 was approximately 65.55; in 1918, 64.29; in 1917, 64.32; in 1916, 63.80; and in 1915 shipments totaled 62.95 of all.

The Gogebic range's shipments in 1920 amounted to 8,763,332 tons, an increase of 2,532,493 over the year previous. The percentage of the Gogebic shipments to the Lake Superior district's grand total was 14.50 in 1920; 12.76 in 1919; 12.63 in 1918; 12.39 in 1917; 12.74 in 1916; and 11.59 in 1915.

The Marquette range shipped 4,608,323 tons last year as compared with 2,992,212 in the year previous, an increase of 1,616,111 tons. The range in 1920 contributed 7.63 per cent. of the total, while its percentage was 6.13 in 1919; 6.93 in 1918; 7.56 in 1917; 8.09 in 1916; and 8.68 in 1915.

Shipments from the Menominee range totaled 6,562,106 tons in 1920, an increase of 2,219,238. The range's percentage of the total movement in 1920 was 10.86 as compared with 9.10 in 1919; 10.15 in 1918; 9.38 in 1917; 9.55 in 1916; and 10.54 in 1915.

The Cuyuna range shipped 2,190,433 tons in 1920, an increase of 329,268 in comparison with the year previous. This range's percentage of the total in 1920 was 3.62; in 1919, 3.81; in 1918, 3.94; in 1917, 3.76; in 1916, 2.57; and in 1915, 2.40.

The Vermillion range's shipments in 1920 amounted to 1,007,435 tons, an increase of 78,386 tons. Its percentage in 1920 was 1.66; in 1919, 1.90; in 1918, 1.90; in 1917, 2.38; in 1916, 2.92; and in 1915, 3.67.

Shipments in 1920 brought the grand totals for the various ranges, since their opening, to the following figures: Mesabi, 557,835,908 tons; Menominee, 127,036,680; Gogebic, 125,725,449; Marquette, 136,121,045; Cuyuna, 13,850,580; Vermillion, 44,186,945; and Mayville-Baraboo, 2,199,787.

Seven mines shipped more than 1,000,000 tons in 1920, the same number as in 1919, while in 1918 more than 12 mines exceeded that figure. Those which shipped more than 1,000,000 tons last year were the Canisteo, 1,127,735 tons; Fayal, 1,045,664; Hartley-Burt-Palmer, 1,249,736; Hull-Rust, 6,994,728; Mahoning, 1,720,538 and Missabe Mountain, 2,354,022, all of the Mesabi range; Newport, 1,155,149 and the Norrie group, 1,610, 128, of the Gogebic. The Oliver Iron Mining Co. operates the Canisteo, Fayal, Hartley-Burt-Palmer, Hull-Rust, Missabe Mountain and Norrie group, while the Steel & Tube Co. of America operates the Newport and the Mahoning Ore & Steel Co., the Mahoning.

Some of the other large shippers in 1920 were as follows: Arcturus, 584,082 tons; Adams, 784,481; Burt-Pool-Day, 602,726; Kerr, 680,873; Leonidas, 555,337; Morris, 948,226; Spruce, 732,417, all operated by the Oliver Iron Mining Co.; Dunwoody, 774,276, of the Pennington Mining Co.; and Grant, 606,383, of the Interstate Iron Co. All of the foregoing mines are on the Mesabi range. On the Menominee, the large shippers were the Chapin, with 850,316 tons, operated by the Oliver Iron Mining Co., and the Penn Iron mine, 524,111, of the Penn Iron Mining Co. On the Gogebic, the largest shippers were the Palms, of the Steel & Tube Co., of America, with 727,224 tons to its credit; Plymouth, of Pickands, Mather & Co., with 712,806 tons, and Wakefield, of the Wakefield Iron Co., 978,694 tons, while on the Marquette the largest was the Cleveland-Cliffs group, with 651,004 tons.

The 14 mines of the Oliver Iron Mining Co. listed in the foregoing shipped a total of 20,120,471 tons, which was more than half the total tonnage shipped from the Mesabi range. The combined tonnage shipped from all other ranges was but 23,261,200 tons. The bulk of the Oliver company's total shipment of 24,936,073 tons came from the 14 mines named, although in 1920 it operated 44 mines.

The Hull-Rust mine's shipment in 1920, 6,994,728, exceeded the total of all mines on either the Menominee, Marquette, Cuyuna or Vermillion ranges. It was within 1,768,604 tons of the amount shipped from the Gogebic range, and it formed approximately one-fifth of all the ore forwarded from the Mesabi range. In 1919 the mine shipped 5,100,555

tons; in 1918, 5,452,585; in 1917, 6,461,443; and in 1916, 7,665,611 tons. It was the only mine from which shipments exceeded 2,000,000 tons in 1920.

The mines which shipped more than 1,000,000 tons in 1919 were the Canisteo, Hartley-Burt-Palmer, Hull-Rust, Kerr, Missabe Mountain, Mahoning and Norrie group. The mines which shipped more than 1,000,000 tons in 1918 were the Adams, Canisteo, Fayal, Hull-Rust, Kerr, Mahoning, Missabe Mountain and Morris on the Mesabi range; Newport, Norrie group and Wakefield, on the Gogebic, and the Cleveland Cliffs group on the Marquette.

The total tonnages of ore produced to date by some of the foregoing mines are as follows: Adams, 23,094,832; Canisteo, 15,809,714; Burt, 16,950,417; Fayal, 30,953,910; Hull-Rust, 58,843,638; Mahoning 31,339,297; Morris, 15,897,247; Norrie group, 39,665,640, and Cleveland-Cliffs group, 30,182,232.

SHIPMENTS BY PORTS AND ALL-RAIL
(Gross tons)

	1915.	1916.	1917.	1918.	1919.	1920.
Escanaba	5,649,289	7,457,444	7,156,854	6,774,969	4,963,358	7,361,070
Marquette	3,099,589	3,858,092	3,207,145	3,457,054	2,132,935	3,415,108
Ashland	5,146,772	8,057,814	7,597,841	7,565,608	5,915,383	8,180,852
Two Harbors	8,642,942	10,735,853	9,990,901	8,723,472	6,424,545	9,278,464
Superior	8,342,793	12,787,046	13,978,741	14,068,341	10,919,965	14,812,398
Duluth	15,437,419	21,837,949	20,567,419	20,567,288	16,821,209	15,479,334
Total by lake	46,318,804	64,734,198	62,498,901	61,156,732	47,177,395	58,527,226
Total by rail	953,947	1,924,268	1,938,102	1,679,440	1,635,127	1,883,251
Total	47,272,751	66,658,466	64,437,003	62,836,082	48,812,522	60,410,477

Six mines began shipping for the first time in 1920 as compared with 10 in 1919. The six are the Hill-Trumbull, of the Cleveland-Cliffs Iron Co., Rouchleau and Wellington, of the Oliver Iron Mining Co., and South Agnew, of the Interstate Iron Co., all on the Mesabi range; Delta, of M. A. Hanna & Co., Menominee range, and Portsmouth of the Hillcrest Mining Co., Cuyuna range.

Ore was shipped from 237 mines in 1920, the total being made up of 114 on the Mesabi range, 39 on the Menominee, 27 Marquette, 25 Gogebic, 7 Vermillion, and 2 Mayville-Baraboo. The total was three less than in 1919 and 47 less than in 1918.

The following shows the average shipments from all the mines on the seven leading ranges.

LEADING SHIPPERS OF THE LAKE SUPERIOR DISTRICT

	1916.	1917.	1918.	1919.	1920.
Mesabi:					
Burt	1,060,487	692,017	747,968	683,205	602,726
Canisteo	1,943,745	1,643,226	1,426,399	1,255,668	1,127,735
Fayal	2,288,799	2,037,705	1,366,083	990,458	1,045,664
Hull-Rust	7,665,611	6,461,443	5,452,585	5,100,555	6,994,728
Leonard	316,468	305,537	737,209	236,358	389,982
Leonidas	1,147,105	795,826	656,735	293,634	555,337
Mahoning	2,215,788	2,524,110	2,024,595	1,237,168	1,720,538
Morris	1,609,971	1,605,701	1,044,558	799,047	948,226
Sauntry-Alpena	933,937	596,049	531,427	422,825	190,652
Sellers	1,344,121	1,575,057	865,070	265,925	176,761
Menominee:					
Bristol	462,559	188,907	245,151	58,183	368,479
Caspian	448,631	411,705	346,028	315,029	421,822
Chapin	557,485	682,349	705,803	524,679	850,316
Marquette:					
Cleveland-Cliffs	1,036,775	946,410	1,050,147	437,475	651,004
Negaunee	523,736	573,760	501,965	424,112	550,297
Gogebic:					
Montreal	530,813	458,658	298,896	319,598	306,660
Newport	1,315,980	1,003,229	1,041,697	915,959	1,155,149
Norrie Group	1,855,863	1,646,606	1,550,802	1,335,468	1,610,128
Wakefield	1,061,730	1,144,411	1,130,432	595,944	978,694
Vermillion:					
Pioneer	507,086	352,497	260,516	376,758	441,017
Zenith	482,783	382,666	243,093	124,721	200,077
Cuyuna:					
Armour No. 2	341,147	273,812	246,362	231,550	286,186
Pennington	206,085	165,895	164,269	100,981	144,403
Mayville-Baraboo:					
Mayville	125,970	93,997	88,812	92,819	78,544

The following table shows the average shipments of all mines on the six leading ranges and of the whole Lake Superior district for 1915–20.

AVERAGE MINE SHIPMENTS

	1915.	1916.	1917.	1918.	1919.	1920.
Mesabi	306,769	397,436	339,715	299,235	278,240	325,783
Vermillion	247,656	243,400	191,336	132,545	132,721	143,919
Gogebic	210,683	339,585	295,618	293,952	249,221	350,533
Marquette	146 621	119,852	194,966	131,946	115,085	170,678
Menominee	124,566	141,430	147,457	130,177	113,919	168,258
Cuyuna	113,611	95,345	115 375	85,476	71,533	95,236
Lake Superior district	226,186	286,087	261,939	222,475	203 385	254,896

Canadian iron-ore mines in the Lake Superior district of which records are available shipped 114,189 tons of ore in 1920 as compared with 167,904 in 1919. The Magpie, of the Algoma Steel Corp., shipped 107,314 or 55,694 tons less than in 1919, while the Moose Mountain, of the Moose Mountain Co., Ltd., shipped 6875, an increase of 1979 tons over 1919.

Imports.—The following table shows the imports of iron ore, in gross tons:

FOREIGN ORE IMPORTS DURING LAST SEVEN YEARS

Country from Which Exported.	1914.	1915.	1916.	1917	1918.	1919.	1920.
Cuba	815,017	831,618	716,571	546,069	632,442	321,753	889 852
Sweden	280,887	204,632	212,063	63,715	.....	61,540	63,861
Spain	66,982	42,092	161,422	152 713	38,385	63,737	69,915
Chile	45 000	146,000	.....	.....	.....	.....	.....
Canada	52,514	84,124	136,835	178,785	115,354	12,383	34,084
Africa	46,175	22,000	.....	.....	.....	.....	.....
Other countries	44,793	10,815	98,845	30,381	1,287	17,048	210,824
	1,351,368	1,341,281	1,325,736	971,663	787,468	476,461	1,268,536

Exports.—Exports of iron ore from the United States in 1920 amounted to 1,145,037 gross tons, as compared with 996,569 tons in 1919 and 1,256,383 tons in 1918.

IRON AND STEEL MARKET

The following review[1] covers the general market conditions during the year in the industry as a whole.

The year 1920 will stand out in the annals of the industry for the maintenance over nearly 11 months of two sets of prices which, in different products, were from $10 to $30 or more apart.

On the one hand, the Steel Corporation, making nearly 50 per cent. of all the steel sold throughout the year, held to the so-called Industrial Board prices which were announced on Mar. 21, 1919. The independent companies in all cases secured higher prices. There was a scarcity of steel for 9 months of the year and the independent companies at times found buyers actually bidding up the market to secure early delivery.

While the Steel Corporation sold bars, plates and shapes—the three leading products—at 2.35, 2.65 and 2.45 cts., Pittsburgh, respectively, the independent companies were able to get, through most of the year, from 3 to 4 cts. for bars, 3.25 to 4 cts. for plates and 3 to 3.50 cts. for structural shapes.

This price situtation was unparalleled. It would not be true to say that the products of the independent mills in 1920 brought from $10 to $30 a ton more than the average of the prices charged by the Steel Corporation. The fact was that some of the independent companies, before 1920 came in, had made large sales for delivery in the first quarter or first half of the year at considerably less than the market prices ruling when such product was delivered. The very high prices of the year—such, for example, as 4 cts. for plates and shapes and 8.50 cts. for No. 28 black sheets (against 4.35 cts. as the Steel Corporation price)—were realized on but a moderate percentage of the year's business.

What happened was that buyers, in view of the scarcity of steel created by the steel strike of 1919, placed orders with two and sometimes three producers. The Steel Corporation had a certain capacity and it had its regular customers. Its prices were attractive; but it had sold farther ahead than the independents in 1919 and entered last year with 8,265,000 tons of unfilled orders on its books. It was not in position to take on prompt-delivery business.

In April, 1920, came the switchmen's strike, which quickly deranged the railroad systems and blocked the movement of steel throughout the country, particularly

[1] *Iron Age*, Jan. 6, 1921.

in the Pittsburgh district. Its serious effects on production and distribution are referred to farther on. It caused even a more frantic scramble of buyers.

It can never be known how far consumers whose deliveries had been set back by the steel strike received their due proportion of mill products in the first half of 1920. But the duplication and triplication of orders in the effort to make sure of getting material did much to sweep the market off its feet. Automobile makers more than any other class were responsible for forcing up prices, many of them determining at all hazards to get steel. Their industry stands out in the record of the year as the one that intensified the apparent scarcity of steel, that caused what were first premium prices to become the market level for early delivery and that later, when its own business began to recede, tried to force a readjustment of prices on automobile steel which led to widespread cancellations of steel orders in other metal-working industries.

There was a feeling in the steel industry, in the summer and early autumn, when other lines were slowing up because of the general strike of buyers against high prices, that for once steel was not a barometer of general trade. Declines in silk, cotton, rubber and wool, which started early in the year, caused a flurry in mercantile lines in May. The automobile slump started in June; but it was September before signs of reaction were noticed in steel. Many in the trade protested that these were not the beginnings of recession and that the industry would run at a good rate practically to the end of the year. October gave a blow to all such hopes. It was proved again that the industries of the country are bound together in a way that makes prosperity in one impossible alongside of depression in another. The steel industry's readjustment might lag a little behind that of others, but it was inevitable.

In early summer, when the automobile slackening started, it was pointed out that the amount of steel required in motor-car manufacture was a small fraction of the total—probably not over 6 or 7 per cent. For a time agricultural-implement manufacturers seemed likely to take up what slack resulted from the automobile depression. Later it was hoped that the railroads with their large advance in freight-rates would be able to buy steel on a liberal scale. Neither of these hopes was realized. The implement makers did some buying, but very shortly the decline in grain markets foreshadowed reduced buying of implements. The railroads set to work to repair cars on an extensive scale and to make them carry heavier loads and travel farther in a day, so that the need of new cars was not as great as it had seemed.

In view of the general impression that the change in the rate of iron and steel buying in the latter part of the year was in the nature of a collapse, and that there was little advance indication of it, some quotations from *The Iron Age's* market summary are in order. These show how cautious sentiment was growing in the industry as far back as August, though October is commonly considered the month of the sudden reckoning. On Aug. 5, when predictions of large railroad buying were flying about, the summary said that the steel trade, having indulged some ill-starred hopes of large railroad orders following the return of the roads in March, was chary of prophesying heavy buying as a result of the late August increase in freight-rates. On Aug. 19 the market was reported less active, "due in part to the price uncertainties connected with the coming railroad freight advance and in part to the recession in the automobile and other industries." The report of Aug. 26 noted that more thought was being given by producers of steel to "the final effect on their own market of the changes going on in other industries." In the next two weeks (Sept. 2 and Sept. 9) conflicting tendencies were noted, causing a waiting market, and it was indicated that the Steel Corporation was not likely to raise its prices to cover the increase in freight-rates on raw materials. It was said then that the steel market was "drifting into

quieter times." From that time on into December the weekly chronicle was progressively unfavorable.

To the student of business history in the intensely interesting period following the signing of the armistice, the price policy of the United States Steel Corporation will appeal as an important factor. When it became plain that the steel that could be rolled before Jan. 1, 1920, would fall short of meeting deliveries due on 1919 contracts, the Steel Corporation rigidly held to the prices of Mar. 21, 1919, which were those decided upon by the Industrial Board. So far as general agreement was concerned, they were abandoned after the refusal of the Railroad Administration early in April, 1919, to pay for rails the prices announced in the Industrial Board schedule—$45 for Bessemer and $47 for open-hearth rails at mill. For a time the independent mills generally adhered to the Mar. 21 schedule, especially those which, owing to the steel strike and fuel scarcity, had large deliveries to make of steel booked at the Industrial Board prices. Some, however, which were not booked far ahead, soon began to ask higher prices and in the fall there were decided differences. By November some independents were asking from $18 to $20 more for steel bars than was the Steel Corporation, and by April, 1920, independent prices were about $32 above the Steel Corporation on steel bars. On sheets the difference was not so marked until early in March, 1920, when it was about $30 on black sheets and by August it had gone to more than $70. The downward trend began to manifest itself distinctly in October, and by the middle of December the prices of independents and those of the Steel Corporation were again the same on all products except tubes and wire nails, on which the Corporation prices were adopted at the end of the year.

The policy of the Steel Corporation was naturally the subject of much discussion among manufacturers of iron and steel and their customers. Those who are particularly friendly to the Steel Corporation claimed for its price policy that it was highly beneficial to business, having had a stabilizing effect and having set an example of moderation in a time when there was a tendency, yielded to by many in the business world, to charge exorbitant prices.

Representatives of independent companies, on the other hand, have had no difficulty in presenting what they consider good reasons for their position. They point out that the Steel Corporation has numerous advantages which they do not enjoy, due partly to the large number, varied character and diverse geographical locations of the Steel Corporation's plants, which give it important advantages in freights under Pittsburgh basing, especially in view of the advances in freight-rates during the past year which have greatly increased manufacturing costs on raw materials and semi-finished products. It is also pointed out that, while the Steel Corporation has maintained low prices on leading products, it has had good profits on various specialties which are seldom mentioned in market reports, and has also obtained higher than its domestic prices on iron and steel products which it has exported.

Mar. 1, 1920, was made an outstanding date in the year for the steel industry by the decision of the Supreme Court of the United States in the Steel Corporation dissolution suit. The court held that the United States Steel Corporation does not constitute a trust in violation of the Sherman act. The decision was by a 4 to 3 vote, with two justices not participating. The court affirmed the unanimous decision of the New Jersey District Court, made prior to the war, and thus put an end to the efforts of the Government to dissolve the Steel Corporation. The decision provided that the Government would be in position to begin new proceedings only in the event that specific violations of law occur in the future.

INDEPENDENT PRICES OF BLACK SHEETS, TANK PLATES, BEAMS AND STEEL BARS GROSS TONS, MAR. 21, 1919, TO DEC. 16, 1920

1919.	Black Sheets No. 28.	Tank Plates.	Beams.	Steel Bars.
April	$97.44	$59.36	$54.88	$52.64
May	97.44	59.36	54.88	52.64
June	97.44	59.36	54.88	52.64
July	97.44	59.36	54.88	52.64
August	97.44	59.36	54.88	52.64
September	97.44	56.67	54.88	52.64
October	97.44	58.46	54.88	53.54
November	97.44	59.36	54.88	60.26
December	97.44	59.36	54.88	61.60
1920.				
January	100.24	60.93	55.33	61.60
February	112.00	78.40	60.48	67.20
March	123.20	81.31	70.11	81.31
April	123.20	84.00	72.80	84.00
May	123.20	84.00	69.44	81.31
June	123.00	79.52	69.44	78.40
July	151.20	75.71	69.44	78.40
August	168.00	72.80	69.44	72.80
September	165.20	72.80	69.44	72.80
October	149.85	69.22	68.32	70.11
November	129.24	62.94	64.74	64.28
December	97.44	59.36	54.88	52.64

STEEL CORPORATION PRICES, GROSS TONS, MAR. 21, 1919, TO DEC. 16, 1920

Black Sheets.	Tank Plates.	Beams.	Steel Bars.
$97.44	$59.36	$54.88	$52.64

PIG IRON, FINISHED IRON AND STEEL AND SCRAP, CHICAGO (a)

	Northern Coke No. 2.	Lake Superior Charcoal.	Southern Coke No. 2.	Common Bar Iron, Cents.	Soft Steel Bars, Cents.	Structural Steel, Cents.	Cast Borings, Net Ton.	No. 1 Railroad Wrought, Net Ton.	Heavy Cast Scrap, Net Ton.	Heavy Melting Steel Scrap, Gross Ton.	Old Steel Rails, Rerolling, Gross Ton.
January	$40.00	$48.75	$44.25	3.24	2.96	2.72	$14.38	$26.00	$37.25	$24.50	$34.25
February	42.25	58.38	45.50	3.63	3.45	3.18	14.63	27.00	38.88	25.00	34.38
March	43.20	58.20	46.40	3.68	3.57	3.50	14.05	27.10	37.85	24.25	32.80
April	43.00	57.25	46.25	3.75	3.70	3.50	14.25	27.25	37.25	23.75	30.63
May	43.00	57.50	47.00	3.75	3.45	3.50	12.88	26.38	37.38	23.00	31.75
June	43.00	57.50	47.00	3.88	3.45	3.45	11.95	25.25	36.30	22.95	32.65
July	45.00	57.50	47.00	3.88	3.45	3.25	12.63	24.88	36.50	24.13	35.00
August	46.00	57.70	47.33	3.88	3.47	3.14	13.45	24.75	36.20	25.35	38.00
September	46.00	58.50	48.67	3.88	3.50	3.23	13.08	23.88	34.00	24.81	38.13
October	45.25	58.50	48.42	3.88	3.31	3.20	11.50	20.25	28.75	21.50	33.44
November	41.50	55.75	45.67	3.75	3.04	3.07	10.65	16.85	23.00	18.45	22.90
December	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Averages:											
1919	29.23	37.03	33.49	2.68	2.74	3.79	10.51	18.65	23.75	18.15	23.44
1918	33.25	37.88	37.75	3.50	3.08	3.18	15.94	29.77	27.71	28.81	33.71
1917	41.13	44.14	40.38	3.77	3.772	4.275	13.64	30.40	20.05	27.86	34.74
1916	20.25	21.33	19.85	2.31	2.94	2.83	6.98	17.16	13.10	16.68	18.59
1915	14.02	16.10	14.73	1.24	1.48	1.48	5.57	10.27	9.96	10.91	11.73
1914	13.60	15.60	14.46	1.06	1.32	1.34	4.61	8.66	9.70	9.37	10.96
1913	15.95	16.50	16.12	1.43	1.55	1.60	5.36	10.80	10.44	10.90	13.33
1912	15.32	16.77	16.11	1.32	1.42	1.46	6.67	12.54	12.29	12.12	14.19
1911	14.87	16.96	14.80	1.22	1.47	1.50	5.34	11.23	11.08	10.92	12.91
1910	17.10	18.67	16.30	1.45	1.62	1.66	5.50	12.99	13.32	13.43	16.34
1909	17.49	19.50	17.30	1.43	1.50	1.59	6.37	13.76	13.79	14.45	15.82
1908	17.57	20.24	16.76	1.56	1.66	1.82	5.37	12.45	12.69	12.45	14.40
1907	24.50	26.56	24.47	1.78	1.77	1.87	8.78	14.63	17.26	15.08	17.53
1906	20.43	20.72	19.44	1.71	1.68	1.86	8.69	15.62	14.55	14.74	17.15
1905	17.65	17.99	16.66	1.65	1.65	1.78	8.57	16.14	13.50	13.97	15.02
1904	14.37	15.50	15.92	1.41	1.50	1.71	4.72	12.45	10.95	10.72	12.54
1903	19.25	22.13	18.31	1.65	1.72	1.75	7.33	16.07	14.75	15.50	19.04
1902	20.86	23.50	20.10	1.71	1.73	1.75	8.89	19.68	15.03	17.37	23.35
1901	15.38	17.50	14.60	1.58	1.58	1.70	4.20	15.00	11.25	12.84	16.05

(a) *Iron Age.*

Another important decision of the year was that of the Federal Trade Commission that the maintenance of the Pittsburgh basing system for fixing steel prices is not in violation of the Clayton anti-trust act and is not an unfair method of competition under the terms of the Federal Trade Commission act. Late in July by a 3 to 2 vote the commission dismissed the application of the Western Association of Rolled Steel Consumers for the issuance of a formal complaint against the United States Steel Corporation and other steel companies. The case had been before the commission for more than a year. In the latter part of September, by a vote of 4 to 1, on representations of the Western Association of Rolled Steel Consumers, the Federal Trade Commission reopened the case. Arguments were made in November by attorneys for the associated consumers and on the other hand by representatives of the Steel Corporation and various independent steel companies. In these extended arguments the method of quoting steel prices f.o.b. Pittsburgh was referred to as the "Pittsburgh Plus" system.

The end of Government control of fuel prices came on Apr. 1 and within a week coke had jumped from $6 per ton at oven to $10 per ton. Profiteering in coal and coke was notorious, and blast-furnace companies which had bought coke on contract found it impossible to get full shipments, as the prices for spot coke continued to rise. For six months exorbitant prices were charged—$18 being paid by a good many furnaces for prompt coke in August and September—and high fuel-cost led to mounting prices for pig iron. The contrary movement was rapid enough when the market turned in late September, and the year ended with prompt coke available at $5.50 at oven.

Pig Iron

The production of pig iron in the United States in 1920 was 36,925,987 gross tons of all kinds, which compares with 31,015,364 tons in 1919, 39,051,991 tons in 1918, 38,621,216 tons in 1917 and 39,434,797 tons in the record year of 1916. The production in the first half of 1919 was 1,540,986 tons more than in the second half. The production in the first half of 1920 was 658,765 tons less than in the second half.

The increase in production in 1920 as compared with 1919 was 16.01 per cent., and it extended to all grades.

MONTHLY PRODUCTION OF PIG IRON, LONG TONS

	1916.	1917.	1918.	1919.	1920
January	3,185,121	3,150,938	2,411,768	3,302,260	3,015,181
February	3,087,212	2,645,247	2,319,299	2,940,168	2,987,879
March	3,337,691	3,251,352	3,213,091	3,090,243	3,357,907
April	3,227,768	3,334,960	3,288,211	2,478,218	2,739,797
May	3,361,073	3,417,340	3,446,412	2,108,056	2,985,682
June	3,211,588	3,270,055	3,323,791	2,114,863	3,043,540
Total first half	19,410,453	19,069,892	18,002,572	16,033,808	18,138,986
July	3,224,513	3,342,438	3,420,988	2,428,541	3,067,043
August	3,203,713	3,247,947	3,389,585	2,743,388	3,147,402
September	3,202,366	3,133,954	3,418,270	2,487,965	3,129,323
October	3,508,849	3,303,038	3,486,941	1,863,558	3,292,597
November	3,311,811	3,205,794	3,354,074	2,392,350	2,934,908
December	3,171,087	2,882,918	3,433,617	2,633,268	2,703,855
Total second half	19,622,339	19,116,089	20,503,675	14,549,070	18,275,128
Grand total(a)	39,032,792	38,185,981	38,506,047	30,582,878	36,414,114

(a) These totals do not include charcoal pig iron and are from *The Iron Age*.

Pig-iron output in the United States since 1820 is given in the following table:

PIG-IRON PRODUCTION FOR 100 YEARS
(Long Tons)

1820.....	20,000	1861.....	653,164	1882.....	4,623,323	1903.....	18,009,252
1828.....	130,000	1862.....	703,270	1883.....	4,595,510	1904.....	16,497,033
1829.....	142,000	1863.....	846,075	1884.....	4,097,868	1905.....	22,992,380
1830.....	165,000	1864.....	1,014,282	1885.....	4,044,526	1906.....	25,307,191
1831.....	191,000	1865.....	831,770	1886.....	5,683,329	1907.....	25,781,361
1832.....	200,000	1866.....	1,205,663	1887.....	6,417,148	1908.....	15,936,018
1840.....	286,903	1867.....	1,305,023	1888.....	6,489,738	1909.....	25,795,471
1842.....	215,000	1868.....	1,431,250	1889.....	7,603,642	1910.....	27,303,567
1846.....	765,000	1869.....	1,711,287	1890.....	9,202,703	1911.....	23,649,547
1847.....	800,000	1870.....	1,665,179	1891.....	8,279,870	1912.....	29,726,937
1848.....	800,000	1871.....	1,706,793	1892.....	9,157,000	1913.....	30,966,301
1849.....	650,000	1872.....	2,548,713	1893.....	7,124,502	1914.....	23,332,244
1850.....	563,755	1873.....	2,560,963	1894.....	6,657,388	1915.....	29,916,213
1852.....	500,000	1874.....	2,401,262	1895.....	9,446,308	1916.....	39,434,797
1854.....	657,337	1875.....	2,023,733	1896.....	8,623,127	1917.....	38,621,216
1855.....	700,159	1876.....	1,868,961	1897.....	9,652,680	1918.....	39,051,991
1856.....	788,515	1877.....	2,066,594	1898.....	11,773,934	1919.....	31,015,364
1857.....	712,640	1878.....	2,301,215	1899.....	13,620,703	1920.....	36,925,987
1858.....	629,548	1879.....	2,741,853	1900.....	13,789,242		
1859.....	750,650	1880.....	3,835,191	1901.....	15,878,354		
1860.....	821,223	1881.....	4,144,254	1902.....	17,821,307		

Below is given the production by half-yearly periods for 1915 to 1920, in gross tons, as compiled by the American Iron and Steel Institute. All pig iron and ferro-alloys are included, whether made in blast-furnaces or in electric furnaces.

Periods.	1915.	1916.	1917.	1918.	1919.	1920.
First half.....	12,233,791	19,619,522	19,258,135	18,227,730	16,278,175	18,133,611
Second half.....	17,682,422	19,815,275	19,389,262	20,824,261	14,737,189	18,792,376
Total.....	29,916,213	39,434,797	38,647,397	39,051,991	31,015,364	36,925,987

Increases in production were made in all states except Massachusetts and Connecticut, as is shown in the following table of production by states.

PRODUCTION OF PIG IRON BY STATES
(In tons of 2240 lb.)

States.	1914.	1915.	1916.	1917.	1918.	1919.	1920.
Massachusetts and Connecticut	6,594	7,802	5,719	10,527	11,485	13,678	10,281
New York.....	1,559,864	2,104,780	2,352,535	2,417,529	2,877,118	2,070,288	2,601,134
New Jersey.....							
Pennsylvania...	9,733,369	12,790,668	16,506,824	15,539,728	15,198,271	12,296,585	13,983,134
Maryland.....	195,594	251,548	501,452	422,212	373,817	244,002	523,733
Virginia.....	271,228	251,346	399,885	520,311	513,737	319,409	429,302
Alabama.....	1,826,929	2,049,453	2,762,885	2,953,705	2,587,852	2,130,092	2,392,962
West Virginia..	(b)236,393	(b)291,040	(b)554,590	561,951	594,675	413,091	772,379
Kentucky.....							
Tennessee.....	216,738	177,729	355,374	369,951	369,822	190,514	283,207
Ohio.....	5,283,426	6,912,962	8,602,895	8,518,603	8,764,132	7,102,627	8,533,470
Illinois	1,847,451	2,447,220	3,922,512	3,456,915	3,440,307	2,558,213	3,280,875
Michigan.....	(a)1,557,355	a1,986,778	(a)2,221,708	2,657,503	3,703,599	2,715,659	2,939,521
Wisconsin, Minn.	329,526	372,966	811,325	738,541	750,366	605,619	711,405
W. of Miss. River	267,777	271,921	437,633	453,742	502,810	375,587	464,584
Total.....	23,332,244	29,916,213	39,434,797	38,621,216	39,051,991	31,015,364	36,925,987

(a) Includes Indiana. (b) Includes Mississippi.

Production of pig iron from 1914 to 1920 according to fuel used is given below:

PIG-IRON PRODUCTION ACCORDING TO THE FUEL USED
(In tons of 2240 lb.)

Fuel Used.	1914.	1915.	1916.	1917.	1918.	1919.	1920.
Coke(a)	22,976,856	29,535,308	38,844,598	37,889,824	38,421,175	30,549,930	36,300,024
Anthracite & coke / Anthracite alone	91,464	84,753	217,788	381,048	283,592	138,337	302,567
Charcoal / Charcoal & coke	263,924	296,152	372,411	376,523	347,224	327,097	323,396
Total	23,332,244	29,916,213	39,434,797	38,647,397	39,051,991	31,015,364	36,925,987

(a) Under coke furnaces are included the very few which use raw bituminous coal. It may be assumed that 99 per cent. of this class of iron was made with coke.

Iron made with coke includes ferro-alloys made with electricity.

Below is listed the production of pig iron according to character of product. Low-phosphorus pig iron, that is, running under 0.04 per cent. phosphorus, is included in Bessemer pig iron; the latter is iron containing from 0.04 to 0.10 per cent. phosphorus. The figures for the last 4 years include under basic iron a small quantity of charcoal iron of basic grade. Nearly all of the charcoal iron is classed as foundry iron; pig iron of high silicon content is included in the foundry group, while under "all other grades" are included white and mottled iron, direct castings, and miscellaneous ferro-alloys.

This table shows the heaviest decreases in Bessemer and basic grades, the foundry nearly holding its own as compared with 1918.

PRODUCTION OF PIG IRON BY GRADES

Years.	Basic.	Bessemer.	Foundry.	Malleable.	Forge.	All Other.	Total, Gross Tons.
1911	8,520,020	9,409,303	4,468,940	612,533	408,841	229,910	23,649,547
1912	11,417,886	11,664,015	5,073,873	825,643	469,183	276,337	29,726,937
1913	12,536,693	11,590,113	5,220,343	993,736	324,407	300,860	30,966,152
1914	9,670,687	7,859,127	4,533,254	671,771	361,651	235,754	23,332,244
1915	13,093,214	10,523,306	4,864,348	829,921	316,214	289,210	29,916,213
1916	17,684,087	14,422,457	5,553,644	921,486	348,344	504,779	39,434,797
1917	17,671,662	13,714,732	5,328,258	1,015,579	345,579	545,278	38,621,216
1918	18,646,174	13,024,966	5,142,607	1,117,914	393,932	726,398	39,051,991
1919	14,494,131	9,975,934	4,916,758	1,009,049	271,286	348,206	31,015,364
1920	16,737,722	12,062,084	5,957,782	1,310,951	318,048	539,400	36,925,987

Of the 36,925,987 tons of pig iron made in 1920, 10,724,298 tons, or 29 per cent., was for sale, and 26,201,689 tons was for the maker's use in 1919 the proportion for sale was 28 per cent.

The number of blast-furnaces in the United States at the close of each year since 1915 is given in the following table:

BLAST-FURNACES IN UNITED STATES

Fuel Used—Blast-furnaces.	1915.	1916.	1917.	1918.	1919.	1920.
Bituminous coal and coke....	390	388	420	.....	.....	419
Anthracite, and anth. and coke	15	20				
Charcoal.....	40	40	35	.....	.....	.....
Total.....	445	448	455	.....	428	419

New blast-furnaces completed in 1920 do not approach the remarkable record made in 1917. *The Iron Age*[1] gives a total of 6, as compared with 2 in 1919, 8 in 1918, 14 in 1917, and 4 in 1916. The six furnaces completed represent a capacity of about 875,000 gross tons of pig iron. For 1921 there is only one blast-furnace under construction, which will probably be completed during the year, having an estimated annual capacity of about 200,000 tons. The following table gives details of new blast-furnaces completed in 1920 and at present under construction:

Company.	Completed in 1920.	Under Construction or Projected.
Trumbull Cliffs Furnace Co., Warren, Ohio.....	..	1
Ford Motor Co., Detroit, Mich.....	2	..
St. Louis Coke & Chemical Co., Granite City, Ill	1	..
Pittsburgh Crucible Steel Co., Midland, Pa.....	1	..
Bethlehem Steel Corporation, Maryland plant.....	2	..
Total.....	6	1

Several companies rebuilt or enlarged their furnaces in 1920 or plan to do so this year. Prominent among these are the Wharton Steel Co., Wharton, N. J.; the Crane Iron Works, Catasauqua, Pa.; the Thomas Iron Co., Hokendauqua, Pa.; E. W. Mudge & Co., Claire furnace, Sharpesville, Pa.; the West furnace of American Rolling Co., Columbus, Ohio; Belfont Iron Works Co., Ironton, Ohio; E. & G. Brooke Co., Birdsboro, Pa., and Lavino Furnace Co., Sheridan, Pa.

STEEL

The statistics of the output of steel in the United States for a number of years past are as follows:

PRODUCTION OF STEEL INGOTS AND CASTINGS FOR 14 YEARS
(In tons of 2240 lb.)

	Acid.								Basic.		Total.
	Bessemer.		Open-hearth.		Crucible, etc.*		Total.		Open-hearth.		
	Tons.	P.c.	Tons.	P.c.	Tons.	P.c.	Tons.	P.c.	Tons.	P.c.	Tons.
1907	11,667,549	49.9	1,269,773	5.5	145,309	0.6	13,082,631	56.0	10,279,315	44.0	23,361,946
1908	6,116,755	43.7	696,304	4.9	69,763	0.5	6,882,822	49.4	7,140,425	50.9	14,023,247
1909	9,330,783	39.0	1,076,464	4.5	130,302	0.5	10,537,549	44.0	13,417,472	56.0	23,955,021
1910	9,412,772	36.1	1,212,180	4.6	177,638	0.7	10,802,590	41.4	15,292,329	58.6	26,094,919
1911	7,947,854	33.6	912,718	3.8	129,602	0.4	8,990,174	37.8	14,685,932	62.2	23,676,106
1912	10,327,901	33.4	1,139,221	3.6	142,679	0.4	11,609,801	37.2	19,641,502	62.8	31,251,303
1913	9,545,706	30.5	1,255,305	4.0	155,237	0.5	10,956,248	35.0	20,344,626	65.0	31,300,874
1914	6,220,846	26.5	903,555	3.8	117,500	0.5	7,241,901	30.8	16,271,129	69.2	23,513,030
1915	8,287,213	25.8	1,370,377	4.3	184,721	0.6	9,842,311	30.6	22,308,725	69.4	32,151,036
1916	11,059,039	25.8	1,798,769	4.2	298,610	0.7	13,156,418	30.7	29,616,658	69.3	42,773,680
1917	10,479,960	23.2	2,061,386	4.6	431,754	1.0	12,972,605	28.8	32,087,507	71.2	45,060,607
1918	9,376,236	21.1	1,982,820	4.5	626,805	1.4	11,985,861	27.0	32,476,571	73.0	44,462,432
1919	7,271,562	21.0	1,229,382	3.5	450,976	1.3	8,951,920	25.8	25,719,312	74.2	34,671,232
1920	8,883,087	21.1	1,296,172	3.1	577,952	1.4	10,757,211	25.6	31,375,723	74.4	42,132,934

* Includes basic electric.

Included in the 31,375,723 tons of basic open-hearth steel ingots and castings produced in 1920 are 3,279,119 tons of duplex steel ingots and castings which were made from metal partly purified in Bessemer converters and finally purified in basic open-hearth steel furnaces, against 2,819,785 tons in 1919, an increase of 459,334 tons, or 16.29 per cent. In 1918 the production of duplex steel was 3,870,017 tons and in 1917 it was 3,791,830 tons.

In 1920 duplex steel was produced by 9 works in 6 states, against 9 works in 6 states in 1919, 10 works in 6 states in 1918 and 1917, and 9 works in 5 states in 1916.

Rails.—The total production of steel rails in the United States in 1920 was 2,604,116 gross tons, against 2,203,843 tons in 1919, an increase of 15.4 per cent. Below is given the record of rail production for the period 1911 to 1920, according to process of manufacture:[1]

PRODUCTION OF ALL KINDS OF RAILS IN GROSS TONS

Years, Rails.	Open-hearth Steel.	Bessemer Steel.	Re-rolled Steel.*	Electric Steel.	Iron.	Total.
1911	1,676,923	1,053,420	91,751	462	234	2,822,790
1912	2,105,144	1,099,926	119,390	3,455	.....	3,327,915
1913	2,527,710	817,591	155,043	2,436	.....	3,502,780
1914	1,525,851	323,897	95,169	178	.....	1,945,095
1915	1,775,168	326,952	102,083	.....	.....	2,204,203
1916	2,269,600	440,092	144,826	.....	.....	2,854,518
1917	2,292,197	533,325	118,639	.....	.....	2,944,161
1918	1,945,533	494,193	101,256	.....	.....	2,540,982
1919	1,893,250	214,121	96,422	50	.....	2,203,843
1920	2,334,222	142,899	126,698	297	.....	2,604,116

* Re-rolled from old steel rails and renewed rails which the manufacturers could not classify as Bessemer or open-hearth.

[1] *Bull.* 2 (1921), Amer. Iron and Steel Inst.

Girder and high T-rails for electric and street railways are included in the figures given above. For recent years the tonnage was as follows: 1914, 136,889; 1915, 133,965; 1916, 127,410; 1917, 91,674; 1918, 20,834; 1919, 112,712; 1920, 100,910 gross tons.

The total production of rails as given above includes, in addition to new rails rolled during the year, rails re-rolled from defective rails and from old rails. The total of renewed or re-rolled rails so included is given in gross tons in the following table.

PRODUCTION OF RENEWED AND RE-ROLLED RAILS, 1913-1920

Years.	Re-rolled from New Seconds, New Defective Rails, etc.			Rolled from Old Rails.	Total Re-rolled.
	Open-hearth.	Bessemer.	Total.		
1914	13,538	13,234	26,772	95,169	121,941
1915	6,477	2,652	9,129	102,083	111,212
1916	1,711	2,149	3,860	144,826	148,686
1917	1,825	7,182	9,007	118,639	127,646
1918	13,296	19,462	32,758	101,256	134,014
1919	1,933	5,766	7,699	96,422	104,121
1920	19,493	1,979	21,472	126,698	148,170

WEIGHT OF ALL KINDS OF RAILS

Years— Gross Tons.	Under 45 Lb. per Yard.	45 Lb. and Less than 85.	85 Lb. and Less than 100.	100 Lb. and Over.	Total Gross Tons.
1911	218,758	1,067,696	1,536,336		2,822,790
1912	248,672	1,118,592	1,960,651		3,327,915
1913	*270,405	†967,313	2,265,062		3,502,780
1914	*238,423	†309,865	868,104	528,703	1,945,095
1915	*254,102	†518,291	742,816	688,995	2,204,203
1916	*295,535	†566,791	1,225,341	766,851	2,854,518
1917	*308,258	†882,673	989,704	763,526	2,944,161
1918	*387,907	†615,165	888,141	592,462	2,533,675
1919	*263,803	†495,577	965,571	478,892	2,203,843
1920	*489,043	†433,333	952,622	729,118	2,604,116

*Includes rails under 50 lb. †Includes 50 lb. and less than 85 lb.

Included above is the annual production of alloy-treated rails, shown separately in the following tables.

PRODUCTION OF ALLOY-TREATED STEEL RAILS

Years.	Total Production, Gross Tons.	Production by Alloys.		Production by Processes.	
		Titanium.	Other Alloys.	Open-hearth and Electric.	Bessemer.
1911	153,989	152,990	999	27,389	115,450
1912	149,267	141,773	7,494	38,539	108,874
1913	59,519	47,655	11,864	40,393	25,952
1914	27,937	23,321	4,616	33,567	490
1915	24,970	21,191	3,779	27,447	603
1916	28,562	26,493	2,069	24,367	887
1917	16,535	15,273	1,262	27,675	*Nil.*
1918	3,111	2,891	220	3,111	*Nil.*
1919	6,476	6,207	269	6,476	*Nil.*
1920	12,909	11,652	1,257	12,909	*Nil.*

Rolled Iron and Steel.—In 1920, the production of all kinds of iron and steel rolled into finished forms (including blooms, billets, and axle

TOTAL PRODUCTION OF ALL KINDS OF FINISHED ROLLED IRON AND STEEL

Years.	Iron and Steel Rails.	Plates and Sheets.	Nail Plate.	Wire Rods.	Structural Shapes.	All Other Finished Rolled Products.	Total, Gross Tons.
1911	2,822,790	4,488,049	48,522	2,450,453	1,912,367	7,316,990	19,039,171
1912	3,327,915	5,875,080	45,331	2,653,553	2,846,487	9,908,475	24,656,841
1913	3,502,780	5,751,037	37,503	2,464,807	3,004,972	10,030,144	24,791,243
1914	1,945,095	4,719,246	38,573	2,431,714	2,031,124	7,204,444	18,370,196
1915	2,204,203	6,077,694	31,929	3,095,907	2,437,003	10,546,188	24,392,924
1916	2,854,518	7,453,980	30,088	3,518,746	3,029,964	15,493,093	32,380,389
1917	2,944,161	8,267,616	22,864	3,137,138	3,110,000	15,585,921	33,067,700
1918	2,540,892	8,799,135	18,310	2,562,390	2,849,969	14,385,058	31,155,754
1919	2,203,843	7,372,814	12,832	2,538,476	2,614,036	10,359,543	25,101,544
1920	2,604,116	9,337,680	20,577	3,136,907	3,306,748	13,941,835	32,347,863

PRODUCTION OF THE U. S. STEEL CORPORATION

Including Tennessee C., I., & Ry. Company

	1915.	1916.	1917.	1918.	1919.	1920.
Iron Ore Mined—	Tons.	Tons.	Tons.	Tons.		
From Marquette Range	618,108	647,132	491,760	338,344	.....	.....
From Menominee Range	939,304	996,983	1,120,382	1,172,319	.....	.....
From Gogebic Range	1,277,419	2,369,460	2,197,554	1,916,220	.....	.....
From Vermillion Range	1,273,825	1,314,002	1,039,807	808,994	.....	.....
From Mesabi Range	17,209,564	24,928,039	23,806,268	21,574,526	.....	.....
In Southern Region	2,351,356	3,099,553	3,125,998	2,522,536	.....	.....
Total	23,669,676	33,355,169	31,781,769	28,332,939	28,893,123	30,828,334
Coke Manufactured	14,500,818	18,901,962	17,461,675	17,757,636	15,463,649	16,208,111
Coal Mined, not used in making coke	5,828,278	6,162,340	6,942,298	6,354,980	5,937,487	6,443,409
Limestone Quarried	5,795,925	7,023,474	6,494,917	5,141,365	5,835,289	5,981,022
Blast Furnace Products—						
Pig iron	13,517,598	17,412,049	15,460,638	15,700,561	13,481,738	14,352,617
Spiegel	7,175	31,486	192,290	240,393	155,766	180,029
Ferromanganese and ferrosilicon	116,735	164,102				
Total	13,641,508	17,607,637	15,652,928	15,940,954	13,637,504	14,532,646
Steel Ingot Production—						
Bessemer ingots	5,584,198	7,273,766	6,405,390	5,630,246	4,788,242	5,402,897
Open-hearth ingots	10,792,294	13,636,823	13,879,671	13,953,247	12,412,131	13,875,063
Total	16,376,492	20,910,589	20,285,061	19,583,493	17,200,373	19,277,960
Rolled and Other Finished Products for Sale—						
Steel rails	1,129,832	1,533,681	1,594,196	1,471,508	1,361,358	1,490,616
Blooms, Billets, Slabs, Tinplate Bars	1,404,443	1,881,526	1,692,348	1,489,737	975,020	1,023,762
Plates	974,741	1,332,262	1,473,625	2,171,362	1,578,360	1,759,263
Heavy Structural Shapes	726,082	1,029,682	1,004,537	1,079,601	855,118	1,040,619
Merchant Steel, Skelp, Hoops, Bands	2,118,366	2,715,277	2,650,970	2,159,279	2,270,711	2,846,686
Tubing and Pipe	919,280	1,338,892	1,234,129	1,190,594	1,192,582	1,429,691
Rods	261,036	278,197	267,071	209,350	161,053	254,968
Wire and Products of Wire	1,771,945	2,004,494	1,821,985	1,445,567	1,438,439	1,757,141
Sheets—Black, Galvanised and Tinplate	1,368,178	1,786,642	1,740,949	1,356,119	1,381,515	1,610,531
Finished Structural Work	476,896	557,953	550,744	503,380	351,704	416,469
Angle and Splice Bars and Joints	190,758	277,271	207,846	145,305	188,707	235,913
Spikes, Bolts, Nuts and Rivets	74,289	95,096	91,980	67,514	39,009	93,464
Axles	95,476	173,530	220,291	141,480	75,494	97,145
Sundry Iron and Steel Products	251,317	456,289	392,240	418,687	91,919	98,415
Total	11,762,639	15,460,792	14,942,911	13,849,483	11,997,935	14,228,502
Spelter	32,031	55,898	67,418	41,715	45,949	63,077
Copperas (Sulphate of Iron)	35,377	46,263	43,942	42,321	35,197	40,291
Universal Portland Cement (Bbl.)	7,648,658	10,425,600	10,917,000	7,287,000	9,112,000	11,960,000

blanks rolled for forging purposes and semi-finished products which were rolled for export in that year) shows an increase of 7,246,319 tons, or 28.87 per cent., as compared with the output in 1919.

Rolled blooms and billets for forging purposes are included above, while semi-finished products rolled for export are included for 1912 and subsequent years.

Electric Steel

The electric-steel production in 1920 was 502,152 tons, an increase of nearly 23.4 per cent. over 1919, of which 233,862 tons was alloy-steel ingots and 11,710 tons alloy-steel castings.

The production of electric steel in the United States is as follows:

1909	13,762
1910	52,141
1911	29,105
1912	18,309
1913	30,180
1914	24,009
1915	69,412
1916	168,918
1917	304,543
1918	511,364
1919	384,452
1920	502,152

While the expansion in the electric-steel industry of the United States and Canada was not as large in 1920 as in 1919, so far as new installations are concerned, the increase was a satisfactory and healthy one.[1] By no means has the industry come to a standstill despite the rapid growth in the war years. In other countries data are still difficult to obtain because of the confusion and rearrangement of industries and countries due to the war, but in this review some definite data have been secured which are of decided value.

On Jan. 1, 1920, according to *The Iron Age's* annual review of the electric-steel industry, the United States was credited with 323 furnaces of all types, with 40 in Canada. On Jan. 1, 1921, this total has been increased to 356 in this country and 43 in Canada. There were only 19 such furnaces in this country and 3 in Canada on July 1, 1913, or eight and one-half years ago. The total in the world on Jan. 1, 1920, was estimated very roughly at about 815. The combined actual and estimated data as of Jan. 1, 1921, show about 961 furnaces of all types in the world's electric-steel industry. The total may actually reach 1000 at the present time.

The review which follows gives complete data to date as to every type of furnace concerning which it has been possible to obtain information, and the product, both in the United States and Canada. The Moore and Volta furnaces are the only exceptions, the companies selling these types supplying no data. The information is particularly accurate as to

[1] Edwin F. Cone, *Iron Age*, Jan. 6 1921.

the United States and nearly complete as to Canada. It has been possible to compile a partially complete table as to the world which is presented in a different form than heretofore. It is hoped to make this more accurate a year from now.

Progress in the United States and Canada in 1920.—The net increase in the number of electric furnaces in the United States in 1920 has been 33 against 36 in 1919, 54 in 1918, 97 in 1917, and 63 in 1916. The total is now 356 against 323 on Jan. 1, 1920; 287 on Jan. 1, 1919; 233 on Jan. 1, 1918; and 136 on Jan. 1, 1917. The apparent net increase of 33 in the last year is less than the actual, due to cancellations of contracts during the year or to the passing out of commission of some installations. The expansion of the industry is appreciated when it is recalled that there were only 19 furnaces, the total is no larger than it was on Jan. 1, 1919.

In Canada the industry is virtually at a standstill. Although the gain the last year has been three furnaces, the total is no larger than it was on Jan. 1, 1919, or 43 furnaces. On Jan. 1, 1917, there were only 19 furnaces in Canada and only 3 on July 1, 1913.

The increase in the two countries has been 36 in 1920 against 33 in 1919, or from 363 on Jan. 1, 1920, to 399 on Jan. 1, 1921.

The total number of Heroult furnaces on Jan. 1, 1921, was 159 in the United States and 18 in Canada, as contrasted with 152 and 18 respectively on Jan. 1, 1920. This is a net gain last year of 7 furnaces, all in the United States; the actual gain was larger, due to cancellations or other changes during the year. As heretofore the Heroult furnace maintains its leadership in installations and output.

The following data, furnished by the Steel Corporation, is of interest as giving a summation of the functioning of the Heroult furnace:

Furnaces used for making ingots	103
Furnaces used for making castings	74
Total	177
Furnaces melting cold scrap	147
Furnaces refining molten metal	8
Furnaces melting or refining	14
Furnaces making malleable iron	5
Furnaces making low-phosphorus iron	3
Furnaces melting ferromanganese	2
Total	179
Number of quarter-ton furnaces	1
Number of one-ton furnaces	10
Number of two-ton furnaces	22
Number of three-ton furnaces	35
Number of four-ton furnaces	2
Number of five-ton furnaces	1
Number of six-ton furnaces	93
Number of 10-ton furnaces	2
Number of 15-ton furnaces	7
Number of 25-ton furnaces	4
Number of 35-ton furnaces	2
Total	179
Total gross tons per charge	1035.25 tons
Average gross tons per charge	5.95 tons
Average net tons per charge	6.66 tons

Most conspicuous in the progress of the American electric-steel industry last year were the Greene and Greaves-Etchells types. Net sales of each of those have increased their total installation by 7 furnaces each. A year ago there were 17 Greaves -Etchells furnaces in the United States against 23 now, with the total for Canada and the United States at 25 Jan. 1, 1921, against 18 on Jan. 1, 1920. Expansion of the Greene furnace has been larger on the Pacific Coast, though its usefulness is gradually spreading eastward. On Jan. 1, 1920, there were 11 Greene furnaces in the United States; on Jan. 1, 1921, there were 18, including two special Greene induction furnaces, particulars concerning which are not yet available but which are awaited with interest.

Expansion in the installations of other types have either been small or nothing. A new furnace of small size but of decided interest and practical use is the Von Schlegell repelling-arc furnace as sold by the Industrial Electric Furnace Co., Chicago, sponsor for the Snyder furnace, which is now classed as multi-phase on single-phase types. The Von Schlegell furnace was described in *The Iron Age*, Dec. 9, 1920. Only one of them is operating in the steel industry, but about 6 are in use in the non-ferrous industry.

TABLE OF THE NUMBER OF ELECTRIC-STEEL FURNACES IN THE UNITED STATES AND CANADA

Type.	U. S. Jan. 1, 1921.	Canada, Jan 1, 1921.	U. S. and Canada Jan. 1, 1921.	U. S and Canada, Jan. 1, 1920.	U. S and Canada, Jan. 1. 1919.	U. S. and Canada, Jan. 1, 1918.
Heroult	159	18	177	170	163	146
Snyder and Von Schlegell	52	2	54	49	48	35
Rennerfelt	17	0	17	18	13	13
Greaves-Etchells	23	2	25	18	11	12
Grönwall-Dixon	11	1	12	13	13	12
Ludlum	13	0	13	12	11	6
Girod	5	0	5	5	5	5
Booth	14	0	14	12	11	4
Moore (a)	22	2	24	20	12	4
Induction	3	0	3	3	3	3
Webb	2	0	2	2	2	2
Stassano	1	0	1	1	1	1
Greene	18	0	18	11	8	1
Vom Baur	5	0	5	4	2	0
Wile	0	0	0	0	0	1
Detroit	1	0	1	1	0	0
Volta	2	8(a)	8			
Special (a)	8	10	20	24	27	24
Total	356	+ 43 =	399	363	330	269

(a) Estimated.

Data regarding the Moore electric furnace and one known as the Volta were not obtainable except from current news sources. Expansion in the case of the former has been good, the total now being estimated at not less than 24 and perhaps as high as 30 in use in this country and

Canada. The Volta furnace, sold by the Volta Mfg. Co., Welland, Ontario, is an outgrowth of the war. It is understood that the United States has been invaded by this furnace and that two are being installed near Pittsburgh. There are at least 6 of these furnaces in Canada and perhaps more.

Development in the World.—For the first time since early in the war it is possible to give some definite data regarding developments in foreign countries or those outside the United States and Canada. A list is at hand of all the Heroult installations in those countries to date as well as data concerning the Rennerfelt, Greaves-Etchells, Snyder and Vom Baur. It has been impossible to present these in detail in this article, but a table has been prepared which is based on these data. Part of this table contains the known installations of these five types in the various countries. These show a total of 53 Heroult furnaces in England, 28 in France, 17 in Germany, 10 in Austria and so on; of the Rennerfelt there are 38 in Sweden, the country of its origin, and 14 in Norway; while of the Greaves-Etchells there are 38 in England, also the country where it originated.

There are therefore 131 Heroult furnaces in foreign countries, with 179 in the United States and Canada, making 310 in the world. This is followed by 99 for the Rennerfelt and 90 for the Greaves-Etchells in the world. Outside of the United States and Canada there are 294 known installations covering four types, with 268 others estimated, bringing the total to 562 outside the United States and Canada. With the 399 in the latter two countries, the world's total is estimated at 961 against an estimate of 815 two years ago.

Of particular interest as to Germany is the use of one 30-ton Heroult furnace by the Dortmander Union and one 28-ton furnace by the Usines Deutscher Kaiser. The Heroult installations in England are none larger than 7-ton and one 10-ton at Sheffield, while in France all are 7-ton or less, except a 25-ton furnace at a plant in Caen, France.

Taking the world's industry as a whole, of the 961 furnaces estimated, the United States is credited with 399 or over 40 per cent. This total is more than the combined total of England, France and Germany, to which are credited 150, 69 and 100, respectively, or 319. Six years ago, or on Jan. 1, 1915, the United States had only 41 furnaces out of 213 in the world, or about 20 per cent. Germany led the world in this industry at that time with 46 furnaces to 41 in the United States. The gradual and healthy expansion in this industry in 1920 is an assurance that the United States will continue to hold the supremacy over Germany and all other countries which it wrested in 1916 and which it has held ever since both in number of furnaces and in production.

TABLE OF ELECTRIC-STEEL FURNACE INSTALLATIONS IN THE COUNTRIES OF THE WORLD, ACTUAL DATA FOR CERTAIN TYPES WITH OTHERS ESTIMATED

Country	Furnaces							
	Heroult.	Rennerfelt.	Greaves-Etchells.	Snyder.	Vom Baur.	Known Installations.	Other Types, Estimated.	Totals.
France	28	2	8	.....	1	39	30	69
England	53	7	38	3	.....	101	49	150
Germany	17	1	.....	.....	.....	18	82	100
Austria (and Hungary)	10	1	.....	.....	.....	11	9	20
Italy	4	.....	4	.....	.....	8	42	50
Luxembourg	2	.....	.....	.....	.....	2	8	10
Russia	3	7	.....	.....	.....	10	5	15
Switzerland	1	1	.....	.....	.....	2	4	6
Spain	4	.....	6	.....	.....	10	0	10
Belgium	2	.....	1	.....	.....	3	2	5
Sweden	3	38	1	.....	.....	42	8	50
Norway	1	14	.....	.....	.....	15	5	20
Japan	2	2	1	2	4	11	0	11
Roumania	1	.....	.....	.....	.....	1	0	1
Chile	.....	1	.....	1	.....	2	3	5
Mexico	.....	.....	.....	.....	1	1	1	2
Finland	.....	5	.....	.....	.....	5	0	5
Denmark	.....	3	.....	.....	.....	3	0	3
Netherlands	.....	2	.....	.....	.....	2	0	2
Brasil	.....	1	.....	.....	.....	1	0	1
China	.....	.....	1	.....	.....	1	0	1
Australia	.....	.....	2	.....	.....	2	0	2
Other South America	.....	.....	3	.....	.....	3	0	3
India	.....	.....	.....	1	.....	1	0	1
Location not given	.....	.....	.....	.....	.....	.....	20	20
Totals	131	85	65	7	6	294	268	562

	Jan. 1, 1921.	Jan. 1, 1920.	Jan. 1, 1919.	Jan. 1, 1918.	Jan. 1, 1917.	Jan. 1, 1916.	July 1, 1913.	March, 1910.
Total outside the U. S. and Canada	562*	.....	.....	464	316	222	118	101
United States	356	323	287	233	136	73	19	10
Canada	43	40	43	36	19	8	3	3
Total in the U. S. and Canada	399	363	330	269	155	81	22	13
Grand total in the world	961	.....	815	733	471	303	140	114

* Largely estimated.

High-speed Steel[1]

It is estimated that the annual production of high-speed steel in the United States is about 15,000 tons. This figure was reached in the last six months of 1919 and the first six of 1920. In 1918 the amount used was approximately 21,000 tons. Owing to very restricted demand the output for the latter part of 1920 and the first part of 1921 will fall short of normal, estimates ranging from 1000 to 3000 tons.

Due to more modern methods of production and the fact that high-speed steel has to some extent taken the place of carbon steel in the tool industry, progress in production in the United States has been such that 1920–21 figures will exceed the normal output of the pre-war years of

[1] C. E. Bregenser, *Iron Age*, June 16, 1921.

1913–14. Prior to that period large quantities were imported from England and Germany.

High-speed steel has a wide field of application in the metal-working industries. It is used for all kinds of metal cutters where a considerable amount of material is to be removed. The following is a list of the principal uses:

Twist drills	Reamers
Lathe tools	Dies
Planer tools	Hobs
Milling cutters	Taps
Forming cutters	Countersinks
End milling cutters	Punches
Inserted tooth cutters	Screw machine tools
Metal cutting saws	Shear disks
Broaches	Shear blades
Automobile valves	Cutter blades

During the last six months of 1919 and the first six of 1920, high-speed steel to the approximate value of $25,000,000 was used for twist drills. Of this amount the automotive industry used approximately 41 per cent.; the machinery and metal-goods manufacturers, 31 per cent.; railroads, 1 per cent.; shipbuilding, 11 per cent.

The following is the order of States according to consumption: Michigan, Ohio, New York, Pennsylvania, Illinois, Connecticut, Massachusetts, New Jersey, Indiana, Rhode Island, Wisconsin, Maryland, Missouri.

Iron-ore Resources of the World[1]

Any attempt to estimate the world's iron-ore resources is complicated both by the diversity of the products manufactured from the raw material and by the numerous factors that go to connote a commercial iron ore. Among these the iron content, the presence of beneficial or deleterious constituents, physical condition, geographical position, and means of transportation are all considerations of the first importance.

First, there is the iron content. It is estimated that the crust of the earth contains 4.4 per cent. of metallic iron, of which only a minute fraction has been sufficiently concentrated by geological agencies to form commercially available iron ores; for one ton of these that contain 60 per cent. of iron there are many tons that contain 50 per cent., while for one ton that contains 40 per cent. there are vastly many more that contain 30 per cent. and so on. The amount of reserves in an iron-ore field can therefore be indefinitely increased by lowering the grade of the material to be included.

With regard to the presence of beneficial or of deleterious constituents, what is prejudicial in one case is beneficial in another. If hematite pig iron for the acid process of steel making is required, low phosphorus is demanded; if, on the other hand, the iron is destined for the basic process, high phosphorus is wanted. Titanium rules out vast bodies of ore containing a large proportion of iron because the presence of titanic acid in any considerable amount raises the temperature of fusion and leads

[1] F. H. Hatch, *London Times*, Trade Supplement; *Metal Trades*, Nov., 1920.

to greater fuel consumption and a heavier blast. A small quantity of manganese, on the other hand, is beneficial, since it helps to get rid of sulphur. A high silica content is objectionable because of the limestone that has to be added to the charge to neutralize the acid, thereby reducing the output per furnace and increasing the cost per ton of pig; but a calcareous ore is sought after, since it is either self-fluxing or can, if the lime is present in excess, be mixed with silicious ores in the proportion required for a fusible charge.

The physical condition of the ore is of the highest importance. If the ore is friable, disintegrates during transportation, and arrives at the smelting works in a dusty condition, or if it "decrepitates" when heated, it chokes the furnace, prevents the free passage of the gases, and leads to dust losses. Although friable ore can be improved by sintering or nodulizing, this can be done only at a heavy increase in the cost of production. On the other hand, a hard, dense ore, such as certain classes of magnetite, is refractory and consequently not favored by the ironmaster, except for enriching purposes.

Summarizing the estimates for the great ore districts that have been at least partly developed (namely, the United States, Cuba, Newfoundland, Brazil, Scandinavia, Central Europe, the United Kingdom, Spain, and North Africa), we arrive at the following round figures: High-grade low-phosphorus ores, 6,740,000,000 tons; high-grade phosphoric ores, 6,460,000,000 tons; low-grade ores, 17,100,000,000 tons; total, 30,300,000,000 tons.

Another 1,500,000,000 should be added for the less important districts of Russia, Austria, Greece, Chile, Venezuela, Mexico, and Canada, making a grand total of 31,800,000,000 tons, of which the equivalent iron is 14,310,000,000 tons, or, on the basis of a pig-iron production of 70,000,000 tons per year, sufficient to last over 200 years.

The resources of the continents of Africa, Asia, and Australia are unknown, but important deposits exist in South Africa, Australia, and India, and others are known, for instance, in China, Korea, and Japan. Moreover, having regard to the large unexplored areas of these continents, the existence of great reserves as yet undiscovered is probable. On the whole, adequate iron-ore supplies seem reasonably secure for a remote future.

World's Production

The following tables give the latest available figures for the world's production of pig iron and steel, together with the figures for the last decade.

PIG-IRON PRODUCTION OF THE WORLD
(In metric tons)

Year.	Austria-Hungary.	Belgium.	Canada.	France.	Germany.	Italy.	Japan.
1910	2,010,000	1,852,090	726,471	4,038,297	14,793,325	215,000	.....
1911	2,095,000	2,046,280	832,376	4,470,141	15,280,527	302,931	53,065
1912	2,312,689	2,301,290	920,636	5,939,194	17,852,571	379,987	56,341
1913	2,369,864	2,484,690	1,024,424	4,207,307	19,291,920	426,775	56,663
1914	2,020,000	1,454,400	710,481	2,690,546	14,389,547	385,114	74,055
1915	1,960,000	68,150	828,920	5,585,776	11,790,199	377,510	64,984
1916	2,418,322	127,825	1,060,787	1,488,691	13,314,238	467,005	77,283
1917	.....	7,990	1,063,084	1,734,967	13,142,247	471,180	.....
1918	.....	*Nil.*	1,084,642	1,306,494	11,754,542	313,576	.....
1919	.....	250,570	832,619	2,412,149	.....	239,710	.....
1920	.....	1,113,000	989,137	3,468,000	.....	.....	377,616*

Year.	Russia.	Spain.	Sweden.	United Kingdom.	United States.	All other Countries.	Total.
1910	3,042,046	367,000	604,300	10,380,723	27,636,687	525,000	66,210,720
1911	3,521,000	408,667	633,800	9,718,638	34,027,940	485,000	73,831,693
1912	4,197,638	403,243	701,900	8,751,464	30,202,568	485,000	73,443,043
1913	4,548,376	424,773	735,000	10,481,917	31,482,406	495,000	79,133,124
1914	4,261,008	425,000	635,100	9,005,898	23,721,115	420,000	62,536,718
1915	3,696,560	439,835	767,600	8,793,659	30,414,817	415,000	64,367,234
1916	3,737,593	497,726	737,300	9,193,656	40,092,043	425,000	73,595,778
1917	3,000,000	357,699	821,200	9,572,190	39,243,018	450,000	72,381,897
1918	.....	386,550	674,900	9,184,974	39,680,728	.....	.....
1919	.....	294,167	497,400	7,517,108	31,514,711	.....	.....
1920	.....	.....	452,300	8,136,827	37,520,495	.....	.....

* Estimated.

STEEL PRODUCTION OF THE WORLD
(In metric tons)

Year.	Austria-Hungary.	Belgium.	Canada.	France.	Germany.	Italy.	Japan.
1910	2,188,371	1,449,500	745,971	3,506,497	13,698,638	635,000	.....
1911	2,363,008	2,192,630	800,504	3,680,613	15,019,333	736,000	10,222
1912	2,785,105	2,515,040	868,811	4,078,352	17,301,998	801,951	12,451
1913	2,682,619	2,466,630	1,060,503	4,686,866	18,958,819	846,085	13,728
1914	2,190,759	1,396,300	751,738	2,655,854	15,619,719	796,152	15,386
1915	2,686,226	98,820	926,157	1,087,700	13,237,646	1,009,240	16,766
1916	3,336,607	99,371	1,295,707	1,951,892	16,182,520	1,269,486	23,861
1917	2,927,789	9,530	1,583,786	2,231,651	16,587,360	1,331,641	.....
1918	1,763,745	10,540	1,699,886	1,807,931	13,756,813	992,523	.....
1919	.....	333,660	934,726	2,186,260	.....	731,823	.....
1920	.....	.....	1,126,753	2,961,508	.....	.....	1,031,550*

Year.	Russia.	Spain.	Sweden.	United Kingdom.	United States.	All Other Countries.	Total.
1910	3,479,000	316,301	468,600	6,477,110	26,512,437	315,000	58,656,312
1911	3,870,000	322,981	456,500	6,565,645	24,054,918	315,000	60,387,354
1912	4,498,000	317,880	508,300	6,904,546	31,751,324	325,000	72,668,758
1913	4,827,000	365,118	582,700	7,787,264	31,822,555	325,000	76,157,262
1914	4,732,000	382,044	500,600	7,918,243	23,904,914	300,000	61,163,709
1915	4,900,000	387,314	588,800	8,687,670	32,686,887	300,000	66,613,226
1916	4,696,000	322,931	717,600	9,344,520	43,462,336	320,000	83,026,332
1917	3,000,000	470,241	681,700	9,909,338	45,786,083	350,000	84,894,119
1918	.....	303,206	524,800	10,434,059	45,178,307	.....	.....
1919	.....	241,189	491,600	8,021,093	35,231,439	.....	.....
1920	.....	.....	426,600	9,202,614	42,811,274	.....	.....

* Estimated.

American Steel and World Supply.[1]—The efforts of France, Belgium and Germany to produce steel in the past two years have had a good deal of attention from the rest of the world. So much had been written about the destruction of French and Belgian plants by Germany and of the crippling of Germany as a steel producer through the loss of Alsace-Lorraine that the working out of the problems of steel makers in all three countries was bound to be watched closely.

The two years since the armistice have given the steel makers of Germany, France and Belgium but little hold in the markets of the world. Statistics of steel output in 1920 in the United States, Great Britain and the three Continental countries emphasize the commanding

[1] *Iron Age.*, Jan. 6, 1921.

share of the United States. For the United States and Great Britain the data given below are complete to December, while those for France and Belgium are based on 10 months' returns. In Germany no iron and steel statistics have been published since November, 1919. The figures given are the average for the first 10 months of that year. They have been repeated for 1920. The German industry was handicapped throughout the past year and it is a question if the output of 1919 was equaled. The figures represent monthly average production, gross tons being used for the United States and Great Britain and metric tons for the other three countries.

ESTIMATED MONTHLY OUTPUT OF PIG IRON AND STEEL IN FIVE COUNTRIES IN 1920, 1919 AND 1913

	1920.	1919.	1913.
Pig Iron:			
United States	3,000,000	2,584,600	2,581,000
Great Britain	645,000	617,000	855,000
Germany	519,000	519,000	1,508,000
France	246,000	289,000	428,000
Belgium	80,800	.....	204,000
Total	4,490,800	4,009,600	5,576,000
Steel Ingots and Castings:			
United States	3,420,000	2,889,270	2,608,000
Great Britain	738,000	658,000	639,000
Germany	632,000	632,000	1,633,000
France	242,600	190,000	385,000
Belgium	97,260	.....	202,300
Total	5,129,860	4,369,270	5,467,300

In 1913 the United States contributed 46.3 per cent. of the pig-iron output of the five countries; in 1919 its proportion rose to 64.4 per cent. and advanced to 66.8 per cent. in 1920. In the other countries pig-iron output has declined since 1913, even Great Britain showing a net loss of about 200,000 tons per month last year, not all accounted for by the coal strike.

In steel the relations are somewhat different, but the United States is even more strongly predominant. Its percentage of the total in 1913 was 47.6, rising to 66.1 per cent. in 1919 and to 66.6 per cent. in 1920. Last year the United States produced more steel than in any year previous to the war. Great Britain also greatly increased its production despite the coal strike.

Another interesting deduction is that while the aggregate steel output of these countries last year fell only about 340,000 tons per month short of the 1913 figures, the pig-iron decline was 1,100,000 tons per month, indicating a much larger use of scrap, from necessity or otherwise. There has been, in fact, a tendency in this country to use less and less pig iron in steel making.

Even handicapped as they all are to-day, it must be said that these European countries stand a better chance of making important increases upon their present share of world trade in steel than the United States

has of maintaining the advantage conferred by conditions during and following the war.

World Steel Demand.[1]—Despite the record-breaking steel exports from the United States in the last two years, the world demand has been far less than it was before the war. An analysis of the steel exports of the five chief producing countries in 1913 and in 1919 and 1920 is highly suggestive and we have put the figures in the following table of monthly averages, using gross and metric tons:

STEEL EXPORTS OF LEADING COUNTRIES—TONS PER MONTH

	1912.	1913.	1919.	1920.*
Germany	456,600	479,800	10,300	.....
United Kingdom	400,600	411,000	185,400	280,000
United States	201,500	241,000	362,100	400,000
France	41,500	48,200	19,400	80,000
Belgium	124,500	128,800	14,500	65,000
Total	1,224,700	1,308,800	594,700	825,000

* Estimated.

The world demand in 1919 was only about 45 per cent. of the pre-war or 1913 exports, while last year, with no data as to Germany, it was about 63 per cent. Before the war Germany was the largest steel exporter, with the United Kingdom a close second and exports from the United States about one-half those of Germany. In the last two years the United States may be said to have taken the place of Germany.

To assume that within a reasonable time the total steel exports of these countries will be again equal to or in excess of those for 1913 involves an increase of 400,000 to 500,000 tons per month over the total movement of 1920. It is of interest to speculate as to the country which will contribute most to this increase. Germany's experience as an exporter of iron and steel and machinery should enable her to build up to 50 per cent. of her old trade, particularly with the advantage she will have with Eastern Europe. It is not improbable that Great Britain will regain her pre-war status; but her labor situation will be a great drawback.

Iron and Steel in Foreign Countries

Algeria.—The shipments of iron ores from Algiers aggregated 758,199 metric tons in 1919, as against 782,047 tons in 1918, 1,065,512 tons in 1917 and 938,684 tons in 1916. Most of the ore is shipped to England.

Australia.—The steel requirements of Australia in the near future will be enormous. The commonwealth could produce annually about 200,000 tons of iron and steel, and the consumption is something like 600,000 tons. The Australian railroads now open to traffic represent 26,000 miles of rails, and much additional trackage is in course of construction or about to be constructed. Some of the lines now building

[1] *Iron Age*, Feb. 3, 1921.

are held up for want of rails and steel accessories. It is a dawning realization of the commonwealth's needs that has led to the various schemes for developing the iron resources of Australia. Deposits of high-grade iron ore are known to exist in New South Wales, Queensland, South Australia and Western Australia. It is also estimated that about 42,000,000 tons of iron ore is obtainable in Tasmania. Iron ore also exists in Victoria, but there are no reliable data to indicate the extent. In 1918–19 Australia imported nearly £17,000,000 worth of machinery and metal manufactures. With adequate supplies of steel much of this could be produced locally. The Government of Queensland, besides exploiting its iron deposits at Bowen, proposes to engage in operations at Cockatoo Island, Western Australia (not to be confused with Cockatoo Island in New South Wales). Queensland's own iron deposits are estimated to be 120,000,000 tons, but the majority are not sufficiently near to the coast for economical working. A mineral survey of the island places the estimated quantity of workable iron ore at 17,000,000 tons.[1]

From time to time there have been stories current of enormous areas of iron ore at Yampi Sound, in northwestern Australia. Recently the State Government dispatched expert mining engineers to examine them, and an exhaustive report has just been supplied, which estimates the amount of iron ore available—that is, in sight above sea-level—at 97,000,000 tons. The quality of the ore is exceptional. Assays show that the percentage of iron runs from 60.91 to 68.99. There is only 1 per cent. of silica present and very little sulphur. Yampi Sound is described as a splendid harbor and can be worked independently of the tides. The ore could be quarried and run down chutes by gravitation into the ships' holds, as there is deep water right up to the base of the deposits.[2]

An expenditure of about £3,500,000 has been decided upon by the directors of the Broken Hill Proprietary Co. (Ltd.) of Australia for extensive additions to the present plant at the Newcastle Steel Works, where already 5000 men are employed. The demands of the commonwealth for adequate supplies of iron and steel for newly established industries as well as increased orders from abroad brought about this decision. Two representatives of this company have been sent to the United States to get information relative to the cost of the required additional machinery, according to advices from Consul General Sammons, of Melbourne. All additions are planned to be completed in two years. Another blast-furnace, making four in all, is to be erected, together with the added number of coke-ovens required. A by-product plant will be used in connection with the coke-ovens. Other additions include a duplex

[1] *Iron Age*, Special Correspondence, July 15, 1920.

[2] *Comm. Rept.*, June 3, 1920.

steel plant, a continuous mill for the rolling of steel bars and billets, a duplication of the present rod-mill, and a sulphuric-acid plant for the supply of acid in connection with the production of sulphate of ammonia and for galvanizing.[1]

Austria.—Owing to increased coal imports into Austria, the iron industry[2] was enabled during 1920 to double its production of crude iron over that of the previous year, according to a report of F. W. Allport, of Vienna. The production during 1920 amounted to 120,000 metric tons as compared with 60,000 tons in 1919. According to an agreement with Czecho-Slovak interests, one-half of the production of the furnaces was given in exchange for coke necessary to continue operation. Owing to the lack of coke one company is reported as smelting with charcoal. Stocks of scrap iron in Austria are reported as decreasing.

The international trade of the Austrian Republic in iron and steel made considerable gains during the last year.[3] In the first half of 1919 there was little production. Figures are available only for the latter half of the year. The exact increase, therefore, for 1920 can merely be estimated. The published records show a total volume of 149,650 tons for the last 6 months of 1919 and 301,333 tons for 1920. The recorded excess of exports over imports was 1461 tons in 1919 and 67,934 tons in 1920. It is noteworthy that in 1919 the Republic imported more finished goods than it exported, but that in 1920 it exported 66,947 tons of finished wares as against 40,552 tons imported, a large favorable balance and a very large gain. Statistics of value are lacking.

Belgium.—According to the latest data the following are the revised figures as to the output of the Belgian iron and steel industry.[4]

	1913.	1915.	1916.	1917.	1918.	1919.
Number of blast-furnace plants at work	19	4	4	1	*Nil.*	8
Number of furnaces in blast	54	6	6	1	*Nil.*	13
Number of days in blast	340	175	222	110	*Nil.*	.....
Number of steel plants at work	29	21	19	31	32	19
Number of iron- and steel-working plants	38	29	29	39	40	26

	1913.	1918.	1919.	1920.[1]
Iron Ore:	150,450	500	4,820	.....
Foundry iron	93,830	.....	43,670	.....
Forge iron	66,370	.....	*Nil.*	.....
Steel making (Bessemer)	32,260	.....	22,930	.....
Steel making (open-hearth)	2,291,290	.....	183,970	.....
Special pig iron	840	.....	*Nil.*	.....
Total pig iron	2,484,690	*Nil.*	250,570	1,128,518
Steel:				
Direct castings	61,850	260		
Bessemer steel	2,192,180	*Nil.*	333,560	1,233,952
Open-hearth steel	212,600	10,280		
Blooms and billets	1,524,990	250	.....	.....
Rolled steel	1,409,460	3,380	214,340	.....
Finished iron	304,350	51,060	68,895	196,532
Finished steel	448,449	13,600	127,820	1,071,856

[1] *Chem. Met. Eng.*, Dec. 22, 1920.
[2] *Comm. Rept.*, Apr. 27, 1921.
[3] *Comm. Rept.*, June 17, 1921.
[4] *Annales des Mines de Belgique.*

The following table shows the progress of Belgian iron and steel production month by month during the year 1920, in metric tons:[1]

Month.	Pig iron.	Finished Iron.	Raw Steel.	Finished Steel.
January	40,820	15,318	56,006	67,651
February	51,773	16,858	70,848	71,250
March	66,009	14,525	78,985	90,508
April	75,686	15,527	100,274	80,667
May	91,842	17,337	98,985	81,331
June	100,967	13,913	112,922	94,894
July	110,494	16,738	118,768	99,737
August	115,015	16,075	123,364	101,312
September	105,960	17,420	111,234	96,702
October	124,692	17,422	121,642	93,433
November	118,410	16,419	119,664	96,445
December	126,850	18,980	121,260	97,926
Total	1,128,518	196,532	1,233,952	1,071,856

Out of the 54 blast-furnaces existing in Belgium in 1913 only 10 were in operation on Jan. 1, 1920. On Jan. 1, 1921, among the 52 blast-furnaces now in existence, 27 were in operation.

In Belgian metallurgy the year 1920 showed, during the first six months, a period of unprecedented prosperity, during which abundant orders at abnormally high prices gave added impetus to reconstruction work, so that by July the general metallurgical production in Belgium had reached 60 per cent. of its pre-war record. The month of June saw rails at 1600 francs a ton, but the price decline of the second half of 1920 and the gradual decrease in demand, together with foreign competition, particularly from German sources, has removed the stimulus for increased production, and while reconstruction work is still vigorously pursued, the production figures for December, 1920, exhibit relatively little variation above those of the preceding July.

In spite of the active reconstruction work which has been carried on in Belgian metallurgical centers since the armistice,[2] this industry is still far from obtaining its pre-war position, according to the report of Trade Commissioner Cross, of Brussels. Particularly in the large plants centering about Liége, regardless of relative success in recruiting skilled labor and in recovering confiscated machinery, it has not been possible during the two years which have elapsed since the armistice to efface the damage done by the invading forces, since the resumption of production has been complicated by the necessity of diverting to repair work a relatively large proportion of the available help.

In the Province of Liége, out of 240 metallurgical plants of all sorts, 10 are completely shut down, 14 are producing less than 25 per cent. of their 1913 quota, 62 are producing between 25 and 50 per cent., 65

[1] *Chem. Met. Eng.*, Mar. 2, 1921.

[2] *Chem. Met. Eng.*, Mar. 2, 1921.

between 50 and 75 per cent., and 63 are producing between 75 and 100 per cent. Only 16 are giving over 100 per cent. of the pre-war production.

Owing to the general destruction of rolling mills and the difficulty of renewing stocks of rolls, Belgian market offerings present a somewhat limited scope, but with the further progress of restoration a wider variety of products may be looked for.

The autumn of 1920 found the Belgian iron and steel industry producing 51 per cent. of its pre-war production of pig iron, 69 per cent. of finished iron, 54 per cent. of steel ingots and 62 per cent. of finished steel, thus indicating notable progress since the beginning of the year. The situation in fuel and raw materials has improved, especially on account of regular supplies of German coking coal and the operations of restored coke ovens.

There was a large increase in exports of iron and steel from Belgium during 1920, as shown in the following table, its figures representing metric tons:

Articles.	1919.	1920.	Articles.	1919.	1920.
Beams	9,366	52,380	Nails and spikes	5,620	21,937
Rails	1,732	51,366	Barbed wire	234	3,409
Sheets	26,742	138,490	Machinery (cast iron)	7,353	29,224
Iron and steel wire or rods	16,165	43,283	Machinery (wrought iron and steel)	8,471	34,420
Tubes and piping	391	4,273			

The principal European markets for Belgian structural iron are France, Sweden, the Netherlands, Spain, and Great Britain; in South America, Argentina (which absorbed one-sixth of Belgian exports in this branch), Brazil, and Uruguay; and in the Orient, British India and the Dutch East Indies. One-third of Belgian rail exports are sold in the Netherlands. Of the rest, 13 per cent. during 1920 was shipped to Spain and 10 per cent. to Egypt. The South American Republics do not depend on Belgium for their rail supplies as much as for structural materials, Argentina being the only notable South American rail purchaser during the past year. France (50 per cent.), Great Britain (9 per cent.), and the Netherlands (8 per cent.), are the largest Belgian customers for sheet iron and steel, while British India, Spain, Japan, Switzerland, and Egypt have bought largely in Belgium during 1920.

A number of Belgian steel plants have formed a combination for joint action after recovery from war damages. This combination is formed for the purpose of distributing raw materials and for the sale of finished products and replaces the former Comptoir des Acieries Belges. The following companies compose the organization: Cugree, Marihaye,

Cockerill, Providence, Angleur, Hainaut, Thy le Chateau, Athus Grivignee, Esperance, Longdoz, Clbecq, Moncheret, Bonehill, Halanzy, and Chatelineau.[1]

Brazil.—According to Brazilian advices, negotiations are proceeding for the shipment of 1,000,000 tons of Itabira iron ore to England. The Itabira Iron Ore Co. has obtained additional powers for the establishment of a smelting plant with an output of 150,000 tons per annum.[2]

Canada.—Following is the preliminary report of the Canadian Department of Mines.

The shipments of iron ore from Canadian mines, which in 1919 were the lowest that had been recorded in 19 years, have again fallen off in 1920 to 127,826 short tons, valued at $510,525, as compared with 197,170 tons valued at $693,386 in the previous year. Were it not for the continued operations at the Magpie and Moose Mountain mines in Ontario, commercial production would practically cease.

The shipments in 1920 included 960 tons of titaniferous ore shipped from Baie St. Paul on the north shore of the St. Lawrence, a little over 1000 tons from Texada Island, B. C., shipped to Seattle, and the balance from the Magpie and Moose Mountain mines.

The Magpie siderite mine in the Michipicoten district of Ontario was operated throughout the year by the Algoma Steel Corporation, the siderite ore being roasted as usual in the rotary-kiln plant at the mine. About 118,990 tons of roasted ore was shipped to the blast-furnace plant at Sault Ste. Marie. The raw ore averages about 34.3 per cent. and the roasted ore about 50 per cent. iron.

Messrs. Moose Mountain, Ltd., operating at Sellwood, Ont., were actively engaged till the end of November in the development of the milling and briquetting processes which are being employed in the treatment of these low-grade magnetites. The raw ore averages about 33.8 per cent. iron, while the briquettes produced during 1920 averaged about 66 per cent. iron. A large tonnage of raw ore was mined during the year, but only a comparatively small quantity, 7664 tons of briquettes was marketed.

In the Great Lakes region ore prices Lake Erie ports were from Feb. 2, 1920: Old Range Bessemer $7.45 per gross ton (basis 55 per cent. iron); Mesabi bessemer $7.20; Old Range non-Bessemer $6.70 (basis 51.5 per cent. iron); Mesabi non-Bessemer $6.55. During the season of 1919 the ruling prices were $1 per ton less than these figures.

The total production of pig iron in Canada in 1920 excluding the production of ferro-alloys was 1,090,318 short tons, having a value of $30,578,253; as compared with a total production in 1919 of 917,346 short tons valued at $24,536,432. Of the 1920 total 1,081,374 tons was made in blast-furnaces and 8944 tons was made in electric furnaces from scrap metal, chiefly shell-turnings. In 1919 the blast-furnace production was 910,080 tons and the electric-furnace production from scrap steel was 7701 tons.

The production of blast-furnace pig iron in Nova Scotia in 1920 was 332,493 tons as against 285,087 tons in 1919. In Ontario the production of blast-furnace pig iron was 748,881 tons, as against 624,993 tons in 1919.

By grades the 1920 production included: basic, 740,598 tons; foundry and malleable, etc., 340,776 tons; low-phosphorus iron (electric furnace), 8944 tons. The

[1] *Comm. Rept.*, Mar. 12, 1921. [2] *Metal. Bull.*

1919 production included: basic, 580,426 tons; Bessemer, 7637 tons; foundry and malleable, etc., 322,017 ; low-phosphorus iron (electric furnace), 7701 tons.

The production of ferro-alloys in Canada in 1920, including ferrosilicon, silico-spiegel, spiegeleisen and ferrophosphorus, all with the exception of the spiegeleisen being made in electric furnaces, was about 27,712 tons valued at $1,433,350. In 1919 the production was 48,601 tons valued at $2,000,809. Over one-half the tonnage made in 1919 was spiegeleisen made by the Algoma Steel Corporation for the company's own use.

The exports of pig iron during 1920 were 102,628 tons valued at $3,628,657, or an average of $35.25 per ton, and of ferro-alloys 25,424 tons valued at $1,297,720. or an average of $51.04 per ton.

The total production of steel ingots and direct steel castings in 1920 (subject to revision) was 1,242,012 short tons, of which 1,176,153 tons were ingots and 65,859 tons direct steel castings.

The total production of steel in 1919 was 1,030,342 short tons. of which 993.039 tons were ingots and 37,303 tons direct castings.

The 1920 production included 25,669 tons of electric-furnace steel, as against 15,502 tons of electric-furnace steel in 1919 and 119,130 tons in 1918.

The exports of steel during 1920 included: billets, blooms and ingots, 69,269 tons valued at $3,696,974, or an average of $53.37 per ton; bars and rods, 85,166 tons valued at $5,687,611, or an average of $86.82 per ton; steel rails, 61,117 tons valued at $2,676, 933, or an average of $43.80 per ton; wire and wire nails valued at $7,407,958; structural steel, 3458 tons valued at $358,294, or an average of $103.62 per ton; scrap iron and steel, 129,015 tons valued at $2,447,684, or an average of $18.97 per ton, together with a large quantity of manufactured iron and steel goods.

China.—The total known reserve of China's ores of such character and situation as makes them available for modern development amounts to about 416,000,000 tons, according to *North China Commerce.*[1] Of this Japanese or Sino-Japanese companies own about 200,000,000 tons. The Chinese Government retains its title to about 130,000,000 tons, including the Molingkwan ores.

The principal deposits owned or controlled by the Japanese are as follows:

Penshihu in Manchuria. Two grades of ore are found here, one containing 68 to 71 per cent. iron and the other 35 to 40 per cent. No figures are available as to how much of the ore is high grade and how much of low grade, but the total tonnage is estimated at 80,000,000 tons.

Anshanshan. The tonnage here is estimated at 30,000,000, and the grade varies from 31 to 66 per cent.

Chinlingchen, in Shantung, where there are 37,000,000 tons and probably more of ore averaging 65 to 70 per cent. iron. The Japanese Government is retaining this deposit to supply the imperial steel works in Japan and seems to be planning to ship ore only.

Tayeh, nominally a Chinese company and actually dominated by Japan. The reserve is about 30,000,000 to 35,000,000 tons, which has already been contracted for delivery in Japan.

[1] *Eng. Min. Jour.*, Sept. 25, 1920.

Tungkuanshan, at one time in possession of the British, now owned through the Sino-Japanese Development Co. by Japanese. This is an over-rated deposit, having only about 2,500,000 tons of probable ore, but being well situated near the Yangtze.

Fangchanghsien, in Anhuei on the Yangtze, with 15,000,000 tons of ore containing 58 to 63 per cent. iron. This is the main reliance of the New Oriental Steel Co., recently floated in Japan.

There is not one important deposit of iron ore in China controlled by foreigners except Japanese, and they now control about one-half the known reserve and are reaching for more. Much of the 86,000,000 tons in the hands of private Chinese firms may be expected to pass into Japanese hands.

The Molingkwan deposits are important because of their grade and situation. A steel works supplied by them would be in position to undersell any other works in China. The ore reserve is 30,000,000 to 40,000,000 tons and the grade is good. The deposits are situated about twenty miles south of Nanking.

China is not as rich in iron as was formerly supposed. The per-capita reserve is less than one-seventieth of that of the United States, and the whole Chinese reserve, including that granted to Japan, amounts to only about 6 years' output from the Lake Superior region.

All these figures take no account of such deposits as those of Shansi for the reason that they are not available for modern industry. The individual bodies of ore there are so small that it is not feasible to mine enough ore in one day to keep a modern furnace running. These deposits are only available to feed small native furnaces which supply a limited local demand for pots and similar articles. From the point of view of modern industry they do not exist.

The output of the Tayeh Iron Mines for 1919 was 762,804 tons; the bulk of the amount exported was absorbed by the Japanese, who have an agreement with the local Chinese company, under the terms of which they control a certain amount of the output. The remainder of the output of the Tayeh mines is consumed by the Hanyang Iron and Steel Works, which turned out 186,071 tons of pig iron, 4850 tons of steel ingots, and 3950 tons of mild steel. The plant was closed down during half of the year. Of the pig iron produced at this mill 62,485 tons was exported abroad, practically all to Japan.

Following are the exports of iron and steel from China during 1919 and 1920, in piculs of 133⅓ lb.:

	1919.	1920.
Pig and unmanufactured	2,710,231	3,065,365
Ore	10,589,375	11,292,407
Manufactures, n.e.s	24,650	129,957
Pans	23,605	27,617
Plates and sheets	14,559	32,494
Bars, billets and nail rod	390	24,686
Rails	305	.....

Cuba.—Shipments of iron ore from Cuba to the United States in recent years were as follows:

Year.	Total.	South Coast.	North Coast.
1920	889,852	.....	.....
1919	321,753	.....	.....
1918	632,442	(a)404,000	(a)228,000
1917	546,069	.....	.....
1916	716,571	.....	.....
1915	831,618	(a)520,000	(a)310,000
1914	815,017	(a)580,000	(a)270,000
1913	1,635,622	(a)1,090,718	(a)491,713
1912	1,397,797	951,621	446,176
1911	1,163,714	775,922	387,792
1910	1,462,498	1,154,798	307,700
1909	936,132	936,132	.....
1908	620,836	620,836	.....

(a) Estimated.

Czecho-Slovakia.—According to returns issued by the Metallurgical Association, of Prague, the output of steel in the Czecho-Slovak works in 1920 amounted to 972,976 metric tons, comprising 163,663 tons of Bessemer and Thomas steel, 792,794 tons of Martin material, and 16,519 tons of electric steel. This is an increase of 186,954 tons on the total figures for 1919, but notwithstanding the improvement in the supply of fuel and the general revival in the industries of Czecho-Slovakia, the production of steel is still below the pre-war level, as shown by the following figures of steel output:

	Metric Tons.
1913	1,257,031
1917	1,601,079
1918	1,019,032
1919	786,022
1920	972,976

France.—The iron and steel output, so far as obtainable in detail, is given in the following tables:

PIG-IRON PRODUCTION IN FRANCE
(In metric tons)

	1913.	1914.	1915.	1916.	1917.	1918.	1919.	1920.
Foundry	953,683	532,250	173,487	378,782	340,588	422,699	.....	797,939
Forge	532,003	268,500	269,157	391,346	405,796	387,878	.....	275,153
Bessemer	124,336	119,666	22,162	68,879	33,817	28,484	.....	76,289
Basic	3,508,837	1,703,566	76,607	561,748	613,533	333,350	.....	2,050,129
Special irons and alloys	88,448	66,564	44,363	87,936	141,233	134,083	.....	117,861
Total	5,207,307	2,690,546	585,776	1,488,691	1,734,967	1,306,494	2,412,149	3,317,371

STEEL PRODUCTION IN FRANCE
(Metric tons)

	Bessemer.		Open-hearth.	Crucible and Electric.	Total.
	Acid.	Basic.			
1911	75,158	2,389,352	1,185,345	30,758	3,680,613
1912	73,917	2,664,610	1,320,462	37,363	4,078,352
1913	252,704	2,806,475	1,582,478	43,209	4,686,866
1914	74,767	1,505,225	1,040,079	35,783	2,655,854
1915	29,827	59,459	944,836	53,578	1,087,700
1916	69,794	513,529	1,290,833	77,736(a)	1,951,892
1917	63,630	574,150	1,498,353	94,518(a)	2,231,651
1918	79,596	315,041	1,312,625	100,669(a)	1,807,931
1919	48,682	1,012,916	1,070,166	59,496(a)	2,186,260
1920	51,063	1,648,294	1,186,908	75,243(a)	2,961,508

(a) Electric, 44,429 tons in1916; 54,031 tons in 1917; 58,222 tons in 1918; 42,559 in 1919; and 56,305 in 1920.

The above figures show an increase of 42 per cent. in the production of pig iron over the production for 1919. The situation in blast-furnaces was progressively improved during the first part of the year, owing to more normal conditions of the railroads. The Spa protocol of July 16, 1920, placing on Germany the obligation of delivering 2,000,000 tons of coal per month to the Entente has increased the amount of coal available for the French metallurgical industry.

The monthly production of pig iron shows an almost steady increase during the year, with the exception of the months of March and April. It reached a climax in October and remained practically unchanged during the last quarter of the year.

In the works of Meurthe-et-Moselle the number of furnaces blown in was augmented from 21 to 33, and the increased coke supplies gave new activity to the works of Lorraine and permitted the blowing in of furnaces which had to be blown out during 1919.

On the other hand, furnaces in the center and south of France which had been active throughout the war, and were blown out owing to the unfavorable conditions in 1919, have remained inactive. There were 93 blast-furnaces in operation on Jan. 1, 1921, as compared with 82 on July 1, 1920, and 69 on Jan. 1, 1920.

The production of steel for the past year is 67.2 per cent. of the pre-war production and represents an increase of 39 per cent. over the 1919 production. Works which were not affected by the invasion of northern France turned out 80 per cent. of the 1913 production. Those of recovered Lorraine only produced 49 per cent. of the pre-war amount.

During the first part of the year the situation was not considered very satisfactory on account of lack of adequate transportation. However, during May and June traffic on the railroads was practically normal.

The difficulty in securing adequate coal supplies also impaired the production.

The prices quoted for coal were constantly increasing. Coal from the north of France which was being paid for at the mine at the rate of 110 francs per ton in January, 1920, increased to 195 francs in May, whereas the same quality of German coal increased from 150 francs to 225 francs; American coal from 320 francs to 440 francs; English coal from 280 francs to 450 francs. Under such conditions long-term deliveries could only be contracted for, and orders accepted at the prevailing prices at the time of completion.

During the latter part of the year the situation improved. There was 1,846,000 metric tons of steel produced during that period, as compared with 1,204,000 tons during the first six months of the year. As a result of the Spa Protocol, deliveries of German coal were increased and old orders could be executed. However, at that time the first effects of the world-wide economic crisis were beginning to be felt, as a result of the high prices quoted for raw material and coal, the difficulty of obtaining banking credits, higher freight-rates on the railroads, and the decrease in funds available for the reconstruction of devastated regions.

A noticeable decrease in prices quoted for iron and steel after Oct. 1 was due to a corresponding decrease in the prices of metallurgical coke, which fell from 245 francs and 275 francs per ton to 175 francs. The decrease in coal prices was not so marked. Therefore, that part of the iron and steel industry which utilized coal was only slightly affected by the reduction of coke prices. Customers, however, waited for further decreases and the complete freedom of trade still impaired by official control. Therefore, the production of raw steel, which reached its climax in October and remained practically unchanged during November, decreased in December as a result of the weakness of the market.[1]

The production of iron ore in France during 1919 and 1920 was as follows, according to *Annales des Mines:*

Field.	Metric Tons. 1919.	Metric Tons. 1920.
Metz-Thionville	7,127,472	8,074,989
Briey-Longwy	809,229	4,181,229
Nancy	669,645	816,201
Total Lorraine	8,606,346	13,072,429
Normandie	322,929	357,200
Pyrénées	257,095	213,782
Other fields	243,419	227,786
Total	9,429,789	13,871,187

[1] Consul Ernest L. Ives, Paris, *Comm. Rept.*, June 23, 1921.

IRON AND STEEL IMPORTS INTO FRANCE
(In metric tons)

	1913.	1917.	1918.	1919.	1920.
Pig iron	32,669	657,022	375,941	95,097	121,462
Blooms, billets and bars	19,379	1,509,169	973,552	523,940	419,019
Wire rods	6,903	54,093	52,483	31,594	27,472
Plates and sheets	13,760	265,132	218,295	261,613	265,782
Tin plates	19,460	45,329	58,192	40,800	76,923
Wire	6,088	84,896	33,288	28,972	12,625
Rails	1,792	121,515	156,861	217,743	27,371
Totals	100,051	2,737,156	1,868,612	1,199,759	950,654

Exports of iron ore from France amounted to 4,407,486 metric tons in 1920, compared with 1,997,171 tons in 1919, 683,460 tons in 1918, and 1,265,331 in 1917. Imports of iron ore were 403,856 tons in 1920, against 303,852 tons in 1919, 143,202 tons in 1918, and 507,909 tons in 1917.

IRON AND STEEL EXPORTS FROM FRANCE
(In metric tons)

	1913.	1916.	1917.	1918.	1919.	1920.
Pig iron	99,730	11,303	17,433	6,999	129,544	296,903
Blooms, billets, and bars	313,741	19,233	32,087	14,568	72,925	394,007
Sheets and hoop iron	11,944	2,251	4,148	3,277	6,706	22,972
Tin plate	2,283	1,180	727	758	1,119	3,070
Wire	5,613	2,375	1,535	961	2,041	29,611
Rails	75,689	1,449	489	1,023	8,703	55,918
Totals	509,000	37,791	56,419	27,586	221,038	802,481

Arrangements have been practically completed for the consolidation of a number of French steel interests, the holding company to be the existing Société Anonyme des Forges et Aciéries du Nord et de l'Est. Its capital will be increased from 46,000,000 to 86,000,000 francs. Among the companies to be acquired are the Société Metallurgique du Nord et de Lorraine and the Usines Métallurgiques de la Basse-Loire. The company will also own some of the important Briey-Longwy and Lorraine iron mines together with six French coal mines and one in England, and will control coke, cement and refractory operations sufficient to supply all raw materials. Control is secured also of rolling mills formerly operated by German interests in Neuenkirchen, Ueckingen and Metz.

Germany.—No statistics of the German steel industry have been made public since late in 1919. For some reason publicity has been stopped and the world is ignorant as to just what the magnitude of the industry is at present. Complete data on pig iron, so far as given out, and for recent years, are as follows:

	Metric Tons.					
	1914.	1915.	1916.	1917.	1918.	1919.
January	1,566,505	874,133	1,078,368	1,082,797	933,570	506,185
February	1,445,511	803,623	1,036,683	943,547	892,788	475,586
March	1,602,896	938,438	1,114,194	1,104,653	1,039,092	558,788
April	1,534,429	938,679	1,073,716	1,131,620	1,084,601	439,975
May	1,607,193	985,968	1,112,574	1,198,171	1,181,794	524,986
June	1,531,333	989,877	1,079,349	1,124,998	1,182,415	531,632
July	1,564,345	1,047,503	1,133,092	1,190,014	1,179,947	580,819
August	586,661	1,050,610	1,145,239	1,185,968	1,155,084	568,785
September	580,087	1,034,124	1,116,752	1,119,635	1,105,366	531,167
October	729,882	1,076,343	1,161,005	1,076,222	1,049,837	.....
November	788,956	1,019,122	1,101,311	1,007,731	516,570	.....
December	853,881	1,029,144	1,161,955	1,976,891	430,478	.....
Total	13,191,679	11,787,564	13,314,238	13,142,247	11,754,542	4,717,923

Production of pig iron by kinds for several years past is noted below. Steel pig includes ferromanganese, spiegeleisen, ferrosilicon, and similar alloys:

	1911.	1912.	1913.	1914.	1915.	1916.	1917.	1918.
Foundry iron	2,881,059	3,355,177	3,640,074	2,494,832	2,283,538	2,019,991	2,012,227	1,499,882
Forge iron	689,881	525,423	489,783	370,257	278,684	216,693	246,288	173,019
Steel pig	1,547,480	2,201,489	2,599,887	1,996,786	1,793,865	2,380,308	2,446,092	2,255,312
Bessemer pig	377 051	388,855	368,840	237,988	187,522	152,660	130,019	115,689
Thomas pig	9,785,056	11,397,965	12,193,336	9,289,989	7,246,322	8,515,086	8,307,571	6,763,592
Total	15,280,527	17,868,909	19,291,920	14,389,852	11,789,931	13,284,738	13,142,247	10,807,494*

*Ten months. Data for 1919 not available.

The following table gives the production according to districts:

PRODUCTION ACCORDING TO DISTRICTS
(In metric tons)

	1914.	1915.	1916.	1917.	1918.
Rhenish-Westphalia	6,610,119	5,165,618	5,749,806	5,932,914	5,817,886
Siegerland and Hessen-Nassau	702,436	789,650	868,544	767,800	702,377
Silesia	853,957	777,625	784,052	751,805	909,506
North and Central Germany	734,659	602,826	663,658	860,878	771,123
South Germany and Thuringia	266,065	234,669	255,325	168,627	168,315
Saar District	954,738	801,597	944,730	898,350	708,863
Lorraine and Luxemburg	4,267,573	2,407,946	4,018,615	3,561,873	2,677,890
Total	14,389,547	11,789,931	13,284,730	13,142,247	11,755,960

The statistics of the German output of steel for recent years, compared with those for 1913, are as follows:

	1913.	1916.	1917.	1918.
Basic Bessemer	10,629,697	7,653,990	7,294,899	5,906,460
Open-hearth	7,610,140	6,856,801	7,274,473	6,170,781
Bessemer (acid)	155,138	175,109	173,430	146,424
Crucible	99,173	108,205	129,784	79,064
Electric	101,755	190,036	219,700	221,824
Steel castings	298,338	1,198,379	1,495,074	1,232,260
Total	18,894,241	16,182,520	16,587,360	13,756,813*

* Ten months.

According to the statistics of the Upper Silesian Mining and Metallurgical Association, the production in Upper Silesia in the first half of 1920 included 15,419,600 tons of coal, 32,700 tons of iron ore, and 258,900 tons of pig iron, while the iron and steel foundries turned out 40,500 tons and the rolling mills 960,700 tons.

The Stahlwerksverband,[1] which is the official title of the German Steel Trust, one of the mightiest and most influential institutions of prewar Germany, has just delivered its death song in the form of the business report, covering the time between July, 1919, and June, 1920, at which time the business activity of the corporation came to an end.

The beginning of the dissolution of the trust dates far back into the early stages of the war, when this powerful structure began tottering on account of the steadily growing tendency of its members to free themselves from all restrictions with regard to production and distribution. The enormous demand for steel products during the war caused the steel trust to be more and more considered as something entirely superfluous, and as a severe handicap to individual progress. It would have fallen into pieces before the war came to an end if the government had not brought influence to bear upon the steel works for the sake of the continuation of the trust. Conditions, however, became critical after the separation of the Luxemburg and Lorraine works. Great difficulty was found to patch up matters from April, 1919, to the end of September, 1919. When, however, at the end of July the Sarre works also left the trust, all hope for a continuation of the trust was abandoned. The Government conceived the idea of a new body, which was to take over the functions of the steel trust, under the control of the government, as far as control of pieces and distribution was concerned.

This body, the Eisenwirtschafsbund, or Iron Economy Society, came into life in April, 1920. Strong pressure has been used from the side of the Government to keep the steel trust alive until operations of the new society came into swing, in such way that the corporation agreement was compulsorily renewed four times until June 3, 1920, when the activities of the trust were terminated definitely.

The last business report of the trust makes sad reading, and is conspicuous for the absence of optimism. It deals very severely with the official institutions for the control of exports, the export licenses, and the slow red-tape business procedure for obtaining them, which were patiently borne by the foreign buyers only as long as the foreign markets stood in great need of German steel products. Many substantial orders at good prices have been lost on the one hand, while the export offices could not prevent large quantities of steel, especially rolled products,

[1] *Eng. Min. Jour.*, Apr. 9, 1921.

bought at inland prices obviously for inland consumption, from finding their way across the frontiers through the "Hole in the West," which is the common term used for the territories now occupied, where control of exports is handled indifferently and very leniently. In this way only 11 per cent. of the total shipments of 1,278,310 tons could be sold abroad. Even the strong inland demand of that period is not looked upon as a hopeful sign, as it was discovered to be artificial and inflated by speculation.

After delivering a parting shot at the steel trust's successor, the Eisenwirtschaftsbund, which, it is said, in the opinion of the steel industry, is perfectly superfluous and out of place, the report gives vent to rather pessimistic views on the present situation and on the outlook, which is declared to be gloomy. The main danger to the German industry is seen in the growing competition of the foreign rivals, whose situation is steadily improving, while the German industry has not seen its worst time yet. The latter is existing solely on the grace of the low exchange, and is thus controlled by a factor which in itself is uncontrollable. A sudden rise of the exchange, like last year's, would land the German steel industry in a sore predicament.

The shipment of semi-finished products in the period covered by the report was 314,762 tons, as against 439,309 tons in the previous year, or 124,547 tons less. Of these shipments only 12,234 tons, or 3.89 per cent., has been sold on foreign order. The shipment of railroad material was 586,814 tons, which is 229,097 tons less than in the preceding year. On foreign order have been shipped 120,886 tons, or 20.46 per cent.; of rolled shapes, 384,743 tons, or 50,077 tons less than the previous year, was shipped, of which only 12,183 tons, or 3.22 per cent., was sold on foreign order. The shipments of steel bars totaled 279,456 tons. The exports of steel bars could have been much higher, says the report, if the steel works had been free from the fetters of government control, this being the more regrettable, as it evidently has caused the loss of several important markets to foreign competitors. The accompanying table shows the year's shipments.

Great Britain.—The statistical bureau of the National Federation of Iron and Steel Manufacturers has issued the following table of production of pig iron by grades in 1916, 1917, 1918, and 1919, in long tons:

	1916.	1917.	1918.	1919.	1920.
Forge	899,467	864,899	772,321	.....	591,500
Foundry	1,418,824	1,162,982	1,296,394	.....	1,417,300
Basic	2,290,549	3,082,562	3,166,556	.....	2,679,700
Hematite	4,042,014	3,993,374	3,538,435	2,374,000	2,940,000
Spiegeleisen, ferromanganese and ferrosilicon	291,845	296,524	246,943	2,782,000	239,000
Direct iron castings, etc.	105,284	20,053	18,780	2,242,000*	140,400
Total	9,047,983	9,420,254	9,039,429	7,398,000	8,000,700

* Includes foundry and forge iron, alloys, etc.

Production of pig iron for a number of years past has been as follows:

	Tons.		Tons.
1907	9,923,856	1914	9,005,898
1908	9,289,840	1915	8,793,659
1909	9,664,287	1916	9,047,983
1910	10,217,022	1917	9,420,254
1911	9,718,638	1918	9,039,429
1912	8,889,124	1919	7,398,000
1913	10,481,917	1920	8,000,700

The following table gives the output of steel ingots in Great Britain, in gross tons:

BRITISH STEEL OUTPUT BY GRADES

	Electric.	Acid Bessemer.	Basic Bessemer.	Acid Open-hearth.	Basic Open-hearth.	Total.
1913	.....	1,048,772	551,929	3,811,382	2,251,793	7,663,876
1914	.....	797,072	482,444	3,680,848	2,874,749	7,835,113
1915	.....	821,408	479,816	4,090,752	2,958,968	8,350,015
1916	.....	1,096,153	505,817	4,393,004	3,012,558	9,196,457
1917	57,156	1,059,281	602,265	4,413,843	3,421,170	9,553,715
1918	103,021	788,355	567,650	3,901,136	3,924,415	9,284,577
1919	47,000	493,000	384,000	2,960,000	3,847,000	7,894,000
1920	52,800	552,800	375,500	3,296,100	4,572,000	9,056,800

The production of steel castings increased from 163,000 tons in 1919 to 207,600 tons in 1920.

IRON AND STEEL EXPORTS, UNITED KINGDOM
(In tons of 2240 lb.)

	1914.	1915.	1916.	1917.	1918.	1919.	1920.
Pig iron	780,691	508,540	790,065	639,281	416,861	356,955	579,455
Wrought iron	90,405	.....	138,095	64,941	41,930	36,337	.....
Sheets	566,601	286,466	277,206	172,139	115,397	133,812	138,100
Plates	199,878	.....	311,452	115,765	112,530	238,551	198,851
Rails	443,636	242,289	50,275	39,000	26,559	125,216	131,079
Steel shapes, etc.	300,653	489,464	617,159	428,445	6,565	38,652	98,085
Tin plates	435,497	368,000	321,654	177,383	223,474	289,462	353,017
All other kinds	1,071,546	1,252,540	850,433	685,849	.....	.....	.....

India.[1]—India possesses enormous deposits of iron ore of high iron content; large deposits of coal where seams occur in great thickness, with excellent roof and floor, and no serious mining difficulties so far, except that large quantities of water must be handled during the rainy season. The deposits of limestone are not within easy distance of the ore occurrences, but deposits of dolomite are known to be sufficient for present requirements. The deposits in Assam of limestone carry unlimited tonnage, as there are frequent breasts 4000 ft. high. There is ample manganese for the requirements of a very large steel industry. The firebricks made from the clays found in the Jherria coal fields are entirely satisfactory. The magnesite occurrences are not large and have the

[1] "Iron and Steel Industry of India," C. P. Perin, *Iron Age*, Oct. 28, 1920.

disadvantages of being rather too pure to frit. In Burma are the principal deposits of the world of wolframite, so that for the manufacture of alloy steel this valuable element is near at hand. In a country with such a dense population as exists in India there need be no shortage of labor.

In 1907 the Tata Iron & Steel Co. was formed and commenced operation about five years later. Kennedy, Sahlin & Co. were constructing engineers and built the first plant, consisting of two blast-furnaces, four 40-ton basic open-hearth furnaces, a combination rail and structural mill, and bar mills of 16-in. and 10-in. trains; 180 non-recovery retort ovens of the Coppè type were installed from motives of economy in first cost. The coke produced from these ovens, from coal dust of the Jherria field, carries from 17 to 20 per cent. ash, and in England or America would be looked upon as a most undesirable blast-furnace fuel, but with high-grade iron ore containing very little silica or alumina, the operation of the blast-furnaces has been reasonably successful from the start. The tonnage of these two original stacks, built to produce 200 tons per day each, have been increased to an average of 375 tons each. The open-hearth furnaces have had their capacity enlarged to tap 58 tons each, and three new furnaces have been added of 75 tons capacity.

Since the successful operation of the Tata steel works other enterprises have been formed, and there are now under construction by the Indian Iron & Steel Co. two modern blast-furnaces. This corporation has secured its iron ores in the Singhbum district, just south of the deposits of the Bengal Iron & Steel Co. Various estimates have been made of the tonnage possessed by this company, but one single deposit, according to their reports, contains over 150,000,000 tons above drainage level of 65-per cent. ore. This company will have to transport its ore over a line now under construction, a distance of about 200 miles to its furnace, which it is proposed to locate in the neighborhood of the coal deposits.

Two other iron and steel projects are in the formative stage, one in the hands of Villiers & Co., in which some of the English ironmasters are taking a substantial interest. This company proposes to build two blast-furnaces not far from Calcutta, in the region of newly discovered coal and iron ore. Here again are to be found single deposits carrying tonnages of iron ore which will seem astounding to those members of the Institute who have been obliged to count with great accuracy their future reserves of iron ore.

The last new venture is in the hands of men who control a large area of coking coal, and they have secured iron-ore deposits variously assumed to contain between 200,000,000 and 300,000,000 tons.

After investigations by some twenty prospectors, engineers of experience, and geologists connected with the different companies who have made these investigations, there is now estimated to be about 20,000,000,000 tons of high-grade ore within a maximum distance of the fuel of 500 miles, and an average distance of 120 to 130 miles. During the war the Tata company added to its reserves of ore a very large tonnage, anticipating a great ultimate increase in the tonnage of pig iron to be produced.

PRODUCTION OF IRON AND STEEL IN INDIA (a)
(In long tons)

	Iron Ore.	Pig Iron.	Ferro-manganese.	Steel.
1916	411,809	244,710	1,843	131,292
1917	413,357	248,132	1,475	162,711
1918	492,669	248,018	13,233	182,269
1919	563,750	307,374	2,650	186,901
1920	.....	317,639	1,183	156,240

(a) *Mining Mag.*, July, 1921.

In regard to the new plant and additions to the old plant of the Tata Iron & Steel Co., about 18 months ago word was cabled to the effect that the plans should not interfere with the growth of the plant ultimately to ten blast-furnaces, with the necessary steel plant. These latter instructions caused serious changes in the plans and made it necessary to put all of the new mills in a new locality with the exception of the plate mill, which was at that time under construction.

The plans which are being carried out for the present development contemplate a total tonnage of 700,000 tons of pig iron and 580,000 tons of steel ingots converted into 425,700 tons of various finished product.

Japan.—Some time ago the Japanese Government appointed a financial and economic committee to investigate the future development of the national iron and steel industry. The report issued by the committee gives the following forecast of the production for the years mentioned, according to the London *Iron and Coal Trades Review:*

Estimated Iron and Steel Production

	Pig Iron, Tons.	Steel, Tons.
1920	377,616	1,031,550
1921	468,000	1,099,000
1922	437,000	1,164,000
1923	466,000	1,227,000
1924	492,000	1,287,000

Coal and Iron Ore Required

	Coal, Tons.	Iron Ore, Tons.
1920	6,040,000	3,709,000
1921	6,473,000	3,978,000
1922	6,926,000	4,275,000
1923	7,339,000	4,517,000
1924	7,773,000	4,786,000

The committee expresses the opinion that the best means of developing the iron industry would be the amalgamation of all the groups of

concerned, and that protective duties are necessary for safeguarding the industry to the extent of 10 per cent. *ad valorem* in the case of pig iron and 15 per cent. on steel, although steel, for the shipbuilding industry, it is suggested, should be admitted free of duty.

The *Asahi* says the importation to Japan of pig iron from America and China is increasing each year, while from England the shipments show a gradual decline.[1] The demand for pig iron in 1914 was 467,282 tons, the output at home being 300,221 tons, and the imports 167,061 tons. Last year the demand amounted to 845,000 tons, and the output at home to 645,000 tons, the imports being 200,000 tons. The imports being 200,000 tons. The imports from China in 1913 were 57,995 tons, but last year the figures increased to 155,258 tons. The following table shows the imports from the United States and England:

	America, Tons.	England, Tons.
1913	400	97,896
1914	3,105	59,834
1915	1,051	36,274
1916	3,875	32,070
1917	24,433	5,681
1918	29,805	8,756

Luxemburg.[2]—The projected economic convention between Belgium and the Grand Duchy of Luxemburg, against which Belgian metallurgical interests have protested, invites attention to the high development of the iron and steel industry in the Grand Duchy. It possesses five groups of iron and steel producers, controlling 70 blast-furnaces, of which 23 are scattered in the Sarre Basin, Lorraine, and Belgium, while 47 are located in Luxemburg itself.

The largest of the Luxemburg plants, the Société Anonyme des Aciéries Reuniés de Burbach-Eich-Dudelange (United Steel Works Co., familiarly known as the "Arbed"), which owns large ore deposits in France and Luxemburg, has at Burbach in the Sarre Basin one section comprising 8 blast-furnaces, of which 3 are in operation; 1 Thomas and 1 Martin converting installation; 14 rolling trains; and some construction shops. At Dudelange it owns 6 blast-furnaces (3 in operation), the same converting plant as at Burbach, and in addition a foundry and 7 rolling trains. This company also operates at Dommeldange construction shops, a steel foundry, Martin converters, and an electric-steel plant with 3 furnaces; the 3 blast-furnaces at Dommeldange are not fired at present. The "Arbed" likewise runs at Esch-sur-Alzette 7 rolling trains, a Thomas converting plant, and 3 of the 6 blast-furnaces installed there

[1] *Far Eastern Rev.*, Sept., 1920.
[2] *Comm. Rept.*, Apr. 6, 1921.

The Ougrée Marihaye Co., which is actually a Belgian concern with its center of business at Ougrèe, on the Meuse just south of Liége, has a section at Rodange, Luxemburg, with 5 blast-furnaces (4 in operation), having an annual production capacity of 125,000 tons, and a Thomas steel plant, as well as foundries and rolling mills. The Ougrèe-Marihaye plants secure their ores from the Grand Duchy and French concessions, their resources in this connection totaling 6516 hectares. The Steinfort Blast Furnace & Steel Mill Co., at Steinfort, now has one of its three blast-furnaces operating and is planning the construction of rolling mills and a steel plant; its ores are located in the Esch Basin. It has lately taken over the Rhenish Steel Works, at Duisburg-Meiderich.

The Société Métallurgique des Terres Rouges (Red Earth Metallurgical Co.), at Esch-sur-Alzette, has 4 blast-furnaces at Audun-le-Tiche (Lorraine), 5 furnaces at Esch-sur-Alzette, and 6 others at Bel-Val, with Thomas converters and 10 rolling trains, having a capacity of 1,000,000 tons of steel annually. None of the furnaces at Esch is operating, but two are fired at Bel-Val and five at Audun. The fifth metallurgical group, that of the Société Anonyme des Haut Fourneaux et Aciéries de Differdange-St. Ingbert Rumelange, familiarly known as the "Hadir," has 3 blast-furnaces at Ottange (Lorraine), 3 at Rumelange, and 10 at Differdange, with a steel plant and 8 rolling trains at the last-named division. Four of the furnaces at Differdange are in operation, and one at Ottange.

The proximity of the Luxemburg steel plants to the ore deposits gives them an appreciable advantage over their Belgian competitors, who since the war have not received the preferential freight-rates on the Belgian railways which until 1914 placed them in a privileged position. The opposition to the Belgian-Luxemburg economic convention therefore emanates entirely from blast-furnace operators, while the steel plants and rolling mills who purchase their pig iron instead of producing it would welcome lower prices on this commodity.

The following table shows the iron and steel production since 1913 in metric tons.

	Iron Ore.	Furnaces in Blast.	Pig Iron Production.	Output of Steel.	Output of Castings.
1913	7,333,372	45	2,547,861	1,182,227	26,513
1914	.....	47	1,827,270	1,136,495	22,954
1915	.....	47	1,590,773	980,384	16,649
1916	.....	47	1,950,514	1,296,407	24,578
1917	.....	47	1,528,865	1,053,596	23,601
1918	.....	47	1,266,671	857,937	19,906
1919	3,112,472	..	617,422	366,231	.....
1920	3,704,390	..	692,935	569,545	.....

New Zealand.—The present session[1] of Parliament has extended the Iron and Steel Industries Act of 1914 until Mar. 31, 1931, which provided

[1] Comm.'Rept., Dec. 27, 1920.

£150,000 to be devoted to the encouragement of the manufacture of iron and steel in New Zealand to be expended at a royalty rate of 12s. per ton for pig iron, puddled bar iron, and steel produced from bar iron, and 24s. per ton for steel produced direct from the furnace. The bounties cover iron produced from iron ore and from iron sand.

Because of the war nothing definite has been done toward the development of the iron or steel industry in the Dominion further than sending samples to England of the iron sands from the North Island, and iron ore taken from Parapara iron fields in the northern part of the South Island, to be tested thoroughly before proceeding with anything definite.

It was lately announced in Parliament that parties were ready to consider the investment of the necessary capital to erect iron and steel works at one or the other of the above sources of supply, and it was also stated that Vickers Ltd. has promised to send out experts to investigate the proposition as soon as they were satisfied that titles and leases to the property were in proper shape. These men are to be authorized to enter into any necessary negotiations in order to bring the undertaking under control if thought desirable.

It is understood that there are very large deposits of iron sand along the west coast of the North Island, with an exceptionally large center near Wanganui, while the iron-ore deposits at Parapara in the north part of the South Island are said to be very rich and extensive and quite easy of access. Such a development might put this country in position to supply quite a large portion of iron and steel products, and thus cut down the large imports along these lines.

Poland.[1]—Under the Russian regime, the Polish iron and steel industry made fair progress, although subject to great difficulties. Before the war there were nine works in Poland, possessing 14 blast-furnaces, of which 11 were working in 1913. The number of workmen employed was 21,500. The war put a stop to progress, the furnaces being extinguished one after the other, whilst the invading armies destroyed the plants with the object of ruining the industry. At the time of the German evacuation, the production had fallen to 800 tons a month, and not more than 2400 workmen were employed. At the beginning of 1919 the iron and steel trade needed from four to five thousand tons of coal monthly, but did not receive more than half this quantity, while coke supplies were even more unsatisfactory. The first blast-furnace recommenced work on July 24, 1919. By Jan. 1, 1920, two were running and four were in blast three months later, but owing to poor fuel arrivals production was irregular. The consequent low output of pig iron had a

[1] *Metal Bull.*, Oct. 12, 1920.

restricting influence on the production of finished iron and steel, with the exception of rolled products. During 1919 16,000 tons of material passed through the rolling mills, and by the end of the year about 5250 men were employed in these mills alone. During the current year further progress has also been made, but the industry is still far behind its pre-war capacity. In March there were four blast-furnaces operating, producing about 4200 tons of pig iron monthly, while four rolling mills, with an approximate monthly output of 2400 tons, were at work.

Russia.—The output of pig iron and steel in Russia from 1907 to 1917 was as follows, in metric tons:

	Pig Iron.	Steel.
1907	2,723,000	2,600,000
1908	2,749,000	2,628,000
1909	2,817,000	3,071,000
1910	3,040,000	3,479,000
1911	3,521,000	3,870,000
1912	4,197,638	4,498,193
1913	4,557,000	4,837,000
1914	4,257,000	4,732,000
1915	3,690,000	4,900,000
1916	3,737,593	.....
1917	3,000,000	.....

From official Russian sources it appears[1] that the mines of Kriwoi-Rog, which before the war contributed about three-quarters of the whole Russian iron production, have in the last year produced nothing.

The total of iron-ore production in 1920 was one-tenth of the quantity expected. In the Ural districts only 9000 workmen instead of 27,000 as before the war are employed.

South Africa.—Considerable importance was attached to the establishment of a blast-furnace at Pretoria, South Africa, in 1918, according to a report of the Bureau of Foreign and Domestic Commerce, for the purpose of producing pig iron from domestic ore. This furnace has a daily capacity of ten to fifteen tons; and though it was in the nature of an experiment, the results obtained were so successful that the promoters now intend to place the industry on a firm and permanent basis. Several other furnaces began operations in the Transvaal, and a company for the same purpose was organized in Natal during 1919. In pre-war days nearly all of the pig iron used in South Africa was imported from Great Britain, the price there being so low that it was not profitable to exploit the local resources. The war conditions induced local capitalists to exploit the iron deposits in South Africa, but for a time considerable doubt was expressed as to whether it was economically feasible to produce pig iron in the country.[2]

The industry is said to have passed now beyond the experimental stage, and it is claimed that pig iron can be turned out in South Africa at a lower cost than in the United States or Great Britain under post-war

[1] *Eng. Min. Jour.*, Mar. 12, 1921.

[2] *Eng. Min. Jour.*, Oct. 2, 1920.

conditions. The promoters express great confidence in being able to supply the domestic demand, besides competing in foreign markets.

The *South African Journal of Industries* has been publishing a series of articles by Professor G. H. Stanley on the production of iron and steel in South Africa and the prospects of an industry founded on African iron ores.[1] In the last of the series, he gives a general résumé of the present position. As yet there has been scarcely more than experimental production of iron or steel from ore in the country, but rapid developments are in progress.

The Newcastle Iron and Steel Co., Ltd., has commenced the erection of a blast-furnace plant at Newcastle in Natal. The furnace is to be 14 by 65 ft., provided with a blowing engine with air cylinders 70 by 60 in., supplied with steam from 1200 hp. boilers, which can be fired with coal dust when gas is not available. The output is expected to be about 100 to 120 tons per day, and the manufacture of cast-iron pipes and other iron and steel castings is contemplated.

Spain.—Except for the year immediately preceding the war, Spanish iron-ore production has never been so great in recent years as in 1908, when a total of 9,271,592 tons were produced. How important a factor the export trade was in the prosperity of the industry is shown by the following comparison of reported production and exports:

Years.	Production, Metric Tons.	Exports, Metric Tons.	Percentage Exported.
1912	9,139,007	8,469,373	92.6
1913	9,861,668	8,907,309	90.3
1914	6,819,964	6,095,121	89.4
1915	5,617,839	4,509,213	80.2
1916	5,856,861	5,045,575	86.1
1917	5,551,071	5,137,621	92.6
1918	4,692,651	4,292,406	91.5
1919	4,640,061	4,702,895	101.3

The production of iron and steel (metric tons) in Spain in the years from 1913 to 1918, inclusive, was as follows:

	1913.	1914.	1915.	1916.	1917.	1918.
Cast iron	666,769	382,043	597,314	322,931	470,241	303,206
Iron and steel				497,726	357,699	386,550

The export of ore has fallen off; the figures for 1919 are given at 4,702,895 tons, as against 8,907,309 in 1913, and as the stock of iron ore at Dec. 31, 1919, was in Viscaya alone 780,000 tons, the output for 1920 is unlikely to show any considerable increase.

The Spanish iron-ore trade with South Wales has always been very large, as quantities of Welsh coal were regularly shipped to Bilbao and iron ores were taken on the homeward voyage. The narrow margin of coal available for export have radically restricted this trade. There are

[1] *Mining Mag.*, Dec., 1920.

signs of Germany coming into the Spanish ore market. In this connection it should be noted that Krupps had a quarter interest in the British Orconera Co., probably the largest open-face mine in Viscaya, but the company is now solely British. Spanish hematite ores of the highest grade are being gradually worked out, and it is probable that some of the mines farther from the coast will soon come into consideration, although the important question of transport is one for which Spain must find a solution.

The increased capacity of Spanish blast-furnaces is important. There are now more than thirty at work, and the output of pig iron and steel is increasing considerably. The principal manufacturers are: (1) Altos Hornos de Viscaya, with factories at Baracaldo and Sestao; (2) Sociedad Metalúrgica Duro Felguera; (3) Fabrica de Nueva Montaña, Santander; (4) Fabrica de Micres, Asturias; (5) Cis. Siderúrgica del Mediterráneo, Sagunto. These firms form a combine, known as the "Central Siderúrgica," which practically controls the output of steel in the country.[1]

Sweden.—The output of iron and steel in Sweden in 1918, 1919 and 1920, according to the statistics of the Swedish Iron & Steel Association, was as follows, in metric tons:

	1918.	1919.	1920.
Pig iron	674,900	497,400	452,300
Puddled iron	92,000	62,300	59,000
Bessemer steel ingots	66,500	56,900	50,300
Open-hearth steel ingots	458,300	412,400	367,100
Rolled and forged iron and steel	361,400	316,900	281,000
Crucible and electric ingots	.....	13,100	9,200

The average pig-iron output during the eight years, 1912 to 1919, was 679,800 tons.

An increase of about 27,000 tons occurred in the export of Swedish iron and steel manufactures during 1920, as compared with 1919. During the last quarter of 1920 the exports amounted to 63,200 tons, as compared with 59,000 tons for the same quarter of 1919. The increase is attributed to the improved market for pig iron, as there always seems to be some demand for Swedish charcoal pig iron. When compared with pre-war figures, however, the 1920 exports seem small. The exports of pig iron alone in 1913 amounted to 186,000 tons, and for 1915, the best year in the history of the Swedish iron industry, to 290,000 tons. As to malleable products, the decline in shipments in 1920 was still more marked, there being a decrease of about 50 per cent., as compared with 1913.

Exports of iron ore during 1920 amounted to 3,740,000 metric tons, as compared with 6,440,000 tons in 1913, 4,500,000 tons in 1918, and

[1] *Iron & Coal Tr. Rev.*, Mar. 18, 1921.

2,430,000 tons in 1919. Germany has taken most of the Swedish iron-ore exports. These large ore exports to Germany are not looked upon with favor by the Swedish iron and steel industry in general, as the German finished products, made in part of Swedish ores, are being sold at much lower prices on the Swedish market than the Swedish manufacturers can produce from their own ores. About 2,000,000 tons of iron ore were exported during the last half of 1920 over Nykoping and Lulea to the following countries: Germany, 1,050,000 tons; Belgium, 49,000 tons; the Netherlands, 122,000 tons; Great Britain, 91,000 tons; and to Finland, 5000 tons. The shipments through Narvik, Norway, amounted in all to 682,000 tons, a large part of which went to Germany.

Foreign competition on the Swedish iron and steel market was more severe during 1920 than during any previous year in the history of the industry, and this condition has resulted in the present unfavorable situation of the Swedish industry.[1]

Switzerland.[2]—The Federal Council officially states that the Society of Study, founded in 1918 at the instigation of the Federal Department of Economics, has by explorations and excavations in the Frickthal, a valley in the northern part of the Canton of Aargau, recently discovered an area of 190 hectares containing 15,000,000 tons of iron ore. In the immediate vicinity, not yet surveyed and excavated, there is estimated an additional amount of 22,000,000 tons. One can realize the importance of this discovery, it is stated, if it is understood that these millions of tons will assure to Switzerland, at pre-war consumption rate, sufficient iron ore to last for 45 years. The Federal Council suggests a provision by the Government of 1,200,000 francs upon condition that a total capital of 4,000,000 francs is raised for exploitation.

Technology

It cannot be said that many new developments characterize the history of the technology of steel in 1920. Such progress as has been made has been steady, but not spectacular. The year was so much taken up with what now develops to have been a false speculative boom that it resembled some of the war years, when more time was given to output than to research.

Blast-furnaces.—The tendency toward larger bosh-angles and wide hearths continued and the suggestion has been made that we may see the bosh-angle increased to its maximum of 90°.

Open-hearth Furnaces.—The most noteworthy development has been the results attained by the use of the McCune or Egler type of open-hearth furnaces. Both of these modifications of the regular open-hearth

[1] *Comm. Rept.*, May 6, 1921.

[2] *Comm. Rept.*, Oct. 20, 1920.

furnace are quite similar and consist primarily in converting the incoming-gas end of the furnace into a "blow-torch" instead of a Bunsen burner as at present. Commenting on this development, *The Iron Age* pointed out that the new principle in the patents referred to involves a throttling of the air supply on the incoming end of the furnace, no matter what the fuel used, and converting that end of the open-hearth furnace into a "blow-torch." The results claimed include a more efficient heat for melting and refining, a more easily regulated as well as a more complete combustion, much lower stack temperatures, and particularly a speeding up of the production. Results already obtained, whether in the Egler or the McCune furnace, indicate an increased efficiency of 20 to 30 per cent. It is stated that a heat which ordinarily takes 12 hr. to complete has been finished in 8 hr., with no harmful effect on the quality of the metal.

Such speeding up of the open hearth means much to the future of the steel industry. Applied generally it would, if successful, result in capacity production from a smaller number of furnaces. It has been suggested also that the lowering of the time in which large heats can be produced has an important bearing on the problem of the 8-hr. shift, in that it would be possible to produce such heats in less than 12 hr. and thus assist in removing what has been advanced as a stumbling block in plants where large heats are the rule.

That so simple an expedient as scientifically regulating the air—by cutting down the supply and placing it under artificial pressure—had not been applied to open-hearth practice earlier is surprising when its efficacy is realized. The general application of the principle, whether by the Egler or McCune furnace or in some other way, may mean for a considerable time the building of fewer furnaces, if all the claims made for it are realized.

Heat-treatment of Steel.—The continued growth of the new technical society, the American Steel Treaters' Society, was so pronounced that at its annual convention and exhibition in Philadelphia in September, 1920, a combination was effected between the new society and the old one at Detroit, known as the Steel Treaters' Society, the result of which was the adoption of the name for the combination of the two societies of American Society for Steel Treating. The second annual convention and exhibition at Philadelphia was very large and a pronounced success.

Molybdenum and Alloy Steels.—Developments in the last three years have brought prominently to the attention of metallurgists and engineers a comparatively new alloy steel. While molybdenum is not as rare an element as was vanadium when it was first introduced, and while it had been incorporated in tool steels some years ago, its use in comparatively

small percentages with or without other alloys in structural steels is of recent origin. Dr. John A. Mathews has stated that he believes that "molybdenum has established for itself a permanent place among alloy steels found useful to the airplane, the automobile and general engineering trades" and he calls attention to several outstanding qualities of these steels, among which are their wide heat-treatment range and the property of unusually deep hardening. There is also freedom from thick and tenacious scale when being rolled.

The physical properties of some of these steels are quite unusual. Besides the points brought out by Dr. Mathews, there have recently been produced some steels which show an elastic ratio of nearly 95 per cent. and a malleability or toughness after case-hardening which is eminently striking. It is of interest, also, that chrome-molybdenum heat-treated steel castings have been made quite recently which possess striking physical properties. An important consideration is that molybdenum is found in quantity within our own borders, whereas some other important alloying metals are almost entirely of foreign origin, a vital consideration in case of war. Regarding molybdenum and other alloy steels, Dr. Mathews says: "It will not wholly displace any other type of steel, but the effect of improvements of this kind and new products has been rather to extend the field of usefulness than to eliminate products of previously demonstrated merit. The Bessemer and open-hearth processes and the electric furnace have not displaced the original crucible cast-steel business."

The foregoing developments are a natural consequence of the rapid growth of the alloy-steel industry in general. In the five years, 1915 to 1919, there were about 7,300,000 gross tons of alloy-steel ingots and castings made in the United States, as compared with some 3,200,000 tons in the five years before the war. Previous to 1909 the production was insignificant by comparison. This development has not reached its its height; in its future progress there is room for all present grades of alloy steel, and for the still newer grades in prospect.

Basic Open-hearth Steel.—The technical sessions of the American Iron and Steel Institute in October, 1920, were featured by two important papers on basic open-hearth steel making. That by F. L. Toy, the third in a series of papers on the open-hearth process, is a voluminous discussion of vital phases of this subject. Despite the improvements that have been made, the author finds "a definite belief among thoughtful open-hearth men that much can be done toward future improvement and that the possibilities are fully as great as ever. The basic open-hearth process embodies a great principle which for many years may find application in our steel-making processes, although, through instruments and

methods of which we as yet have no conception or knowledge, we have not yet the vision that lets us see them in terms of their ultimate economic value to us."

The basic is the most complicated of the steel-making processes, involving as it does so many chemical reactions. Its use is growing the world over. It now contributes about 80 per cent. of the American open-hearth steel output and its use in England has advanced strikingly in recent years. As a result the quality of basic open-hearth steel has improved until there are those who claim that it can be made or is produced equal to acid open-hearth steel.

The other paper deals ably with the use of high-manganese pig iron in the basic open-hearth process. Mr. Wheaton clearly shows the progress in this comparatively new development. The benefits set down, from the blast-furnace practice down through the open hearth to the savings in the rolling of finished products, are highly important and will commend themselves to such as have not yet appreciated the possibilities.

Without doubt still greater developments in the matters presented by the two papers are in store for steel-makers. It has been demonstrated that the basic electric furnace, in duplexing or triplexing, accomplishes the same results as the more complicated and longer reactions of the basic open hearth, with or without manganese, and probably better results. Is it not likely that when, in the course of time, the super-power projects are realized over the country and electricity is obtained from water-powers on a greater and cheaper scale, large-unit electric furnaces will refine hot metal from the converter or the open-hearth, or from the mixer direct, into high-quality steel on a scale beyond anything regarded as practical today?

LEAD

By H. B. Pulsifer

Total production of lead in the United States in 1920, according to preliminary statistics issued by the Geological Survey, including that derived from foreign and domestic ores, was approximately 530,000 short tons, as compared with total production in 1919 of 424,433 tons. Antimonial lead output decreased from 13,874 tons in 1919 to 12,535 tons in 1920. Exports were 23,500 tons derived from foreign material, and 2730 tons from domestic ores, indicating a total decrease during the year of 28,000 tons from the total 1919 outgo. Imports, owing to the decline in prices abroad and to the low exchange rates were heavy, 35,719 tons of refined lead coming to our ports during the year. A most unusual feature developed as a result of the importations, in the fact that prices were affected to such an extent as to decline sharply in meeting competition from foreign metal.

Prices fluctuated during the year from 9.25 cts., the highest level, to 4.45 cts. per lb., the lowest level. Unlike copper and tin, at the end of the first half of the year, June 30, prices showed a net advance. The basis of the leading interest was up ¼ ct. per lb. to 8.00 cts., from 7.75 cts. Jan. 1. In the outside market, East St. Louis was up 47½ points from 7.62½ to 8.10 cts., while New York had advanced 60 points, owing to scarcity at this point, from 8.00 cts. Jan. 1 to 8.60 cts. June 30.

METALLURGICAL PRODUCTION OF LEAD IN THE UNITED STATES (a)
(Refinery statistics. In tons of 2000 lb.)

Year.	Domestic Origin.					Foreign Origin.		Grand Total.
	Desilverized.	Antimonial.	S. E. Mo.	S. W. Mo.	Total.	Desilverized.	Antimonial.	
1914.....	318,697	17,177	177,413	25,448	538,735	28,475	1,119	568,329
1915.....	305,160	24,601	185,849	20,312	535,922	43,301	2,883	582,106
1916.....	330,189	22,819	206,105	33,128	592,241	17,832	3,304	613,377
1917.....	319,015	16,265	205,861	40,575	581,716	50,962	2,991	635,669
1918.....	284,733	18,658	189,207	63,635	556,233	98,596	2,083	656,912
1919.....	226,085	14,864	158,182	55,790	454,921	61,380	1,547	517,848
1920.....	236,912	8,992	206,836	29,004	471,744	51,700	2,197	525,641

(a) From *Eng. Min. Jour.*

During the second half, however, the arrivals of foreign lead increased to such an extent that prices declined, showing by the end of September a decline of ¼ ct. New York to 7.75 cts. per lb.; East St. Louis was off ⅛ ct. to 7.50 cts., and the American Smelting & Refining Co.'s basis was

PRIMARY REFINED LEAD AVAILABLE FOR CONSUMPTION IN THE UNITED STATES[1]

(Short tons)

	1915.	1916.	1917.	1918.	1919.	1920.
Supply:						
Stock in bonded warehouses Jan. 1	7,668	12,169	12,369	26,612	17,471	45,710
Imports—						
For consumption	9,780	10,878	7,087	105,530	62,894	35,719
For warehouse	41,116	24,452	71,185			
Increase by liquidation	2,250	5,642		800		
Production from all ore and bullion	507,026	552,228	548,450	539,905	424,433	529,657
Total supply	568,440	605,369	639,091	672,847	504,798	611,086
Withdrawn:						
Exports of foreign lead—						
From warehouse	38,618	9,880	37,652	59,416	40,976	17,363
In manufactures, with benefit of drawback	3,983	5,171	7,537	3,426	1,936	6,175
Exports of domestic lead	87,306	100,500	53,688	41,832	10,510	2,730
Decrease by liquidation			297			
Stock in bonded warehouses Dec. 31	12,169	12,369	26,612	17,471	45,710	52,542
Total withdrawn	142,076	127,920	125,786	122,145	99,132	78,810
Available for consumption	426,364	477,449	513,305	550,702	405,666	532,276

[1] U. S. Geol. Surv.

AMERICAN SILVER-LEAD SMELTING WORKS

Company.	Place.	Furnaces.	
		No.	Annual Capacity.
American Smelting & Refining Co	Denver, Col	7	510,000
American Smelting & Refining Co	Durango, Col	4	210,000
American Smelting & Refining Co	East Helena, Mont	4	330,000
American Smelting & Refining Co	El Paso, Tex.	6	380,000
American Smelting & Refining Co	Leadville, Col	8	510,000
American Smelting & Refining Co	Murray, Utah	8	700,000
American Smelting & Refining Co	Omaha, Neb	2	82,000
American Smelting & Refining Co	Perth Amboy, N. J	4	170,000
American Smelting & Refining Co	Pueblo, Col	7	380,000
American Smelting & Refining Co	Selby, Cal	3	210,000
Anaconda Copper Mining Co	Great Falls, Mont	1	90,000
Bullshead Mining & Smelting Co	Spruce Mtn., Nev., P. O. Reno	1	11,000
Bunker Hill & Sullivan M. & C. Co	Kellogg, Idaho	3	300,000
International Smelting Co	Tooele, Utah	5	600,000
Northport Smelting & Refining Co	Northport, Wash	2	216,000
Ohio & Colorado Smelting & Refining Co (a)	Salida, Col	4	360,000
Pennsylvania Smelting Co	Carnegie, Pa	2	60,000
U. S. Smelting, Ref. & Mng. Co	Midvale, Utah	7	530,000
Totals, United States		78	5,649,000
American Smelting & Refining Co	Aguascalientes	1	50,000
American Smelting & Refining Co	Chihuahua	7	400,000
American Smelting & Refining Co	Monterrey, N. L	7	410,000
American Smelting & Refining Co	Velardena	3	150,000
Mazapil Copper Co	Saltillo, Coah	3	105,000
Cia. Metalurgica Mexicana	San Luis Potosi	10	360,000
Cia. de Minerales y Metales (b)	Cerralvo, N. L	2	38,000
Cia. de Minerales y Metales (c)	Guadalupe, N. L	1	77,000
Cia. Fundidora y Afinadora de Monterrey (d)	Monterrey, N. L	4	238,000
Cia. Minera de Peñoles (e)	Mapimi, Dur	6	310,000
Cia. Metalurgica de Torreone (e) (f)	Torreon, Coah	8	286,000
Totals, Mexico		52	2,424,000
Consolidated Mining & Smelting Co	Trail, B. C	4	220,000

(a) Sold during 1920. (b) Not in operation since Jan. 23, 1917. (c) Not in operation in 1919. (d) Smelter under lease to Cia. de Minerales y Metales. (e) Subsidiary of Cia. de Minerales y Metales. (f) Not in operation since Feb., 1919.

off ¼ ct., and back to 7.75 cts. again. In the last 3 months, with foreign arrivals still in the market and the generally adverse conditions becoming more aggravated, the decline was rapid and continuous. The year closed with the leading interest quoting 4.75 cts. per lb. New York and East St. Louis, while in the outside market 4.60-4.70 cts. East St. Louis, 4.62½ cts. New York were the final quotations.[1]

Imports.—The imports of refined pig lead, which for the year 1916 to 1919 inclusive had been a little over 5000 tons a year, jumped in 1920 to about 34,000 tons. This was a result of the relations of the New York and London prices and the rate of exchange, which not only made it profitable to re-import domestic lead into the United States (which came in duty-free), but also to import foreign pig lead. Up to the end of November 9425 tons of refined lead had come in from Mexico, 1680 tons from France, and 12,978 tons from England. Some transshipped Spanish and Australian lead is included in these quantities.[2]

PIG LEAD EXPORTED FROM THE UNITED STATES
(In pounds)

Destination.	1918.		1919.		1920.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value
Denmark	647,048	$55,453	2,883,031	$227,778	851,200	$53,197
France	1,746,541	131,060	6,656,171	452,719	2,061,393	155,892
Italy	3,148,617	220,515	.....	.....	.....	.....
Netherlands	.....	.....	1,724,949	95,721	3,763,441	311,493
Russia in Europe	230,156	18,412	4,000	280	.....	.....
Sweden	911,660	73,752	951,357	60,482	1,176,000	99,280
United Kingdom	126,909,858	8,921,786	46,404,068	2,851,214	5,382,207	397,502
Canada	31,587,591	2,094,612	4,147,181	242,987	3,443,536	223,945
Argentina	2,308,624	176,748	6,237,203	312,766	2,600,658	178,260
Brazil	3,837,896	294,195	3,743,199	268,315	4,936,127	376,919
China	533,339	35,988	1,273,194	66,791	344,897	32,263
Japan	17,231,731	1,218,430	23,687,710	1,077,394	7,952,080	622,688
Russia in Asia	598,733	50,910	5,100	425	.....	.....
Other countries	2,539,382	202,923	4,319,451	294,175	6,621,213	499,147
Total	192,231,176	$13,494,784	102,036,614	$5,951,047	39,132,752	$2,950,586
Total from domestic ore	83,662,322	$5,889,381	22,320,299	$1,533,354	.....	.....
Total from foreign ore	108,568,854	7,605,403	79,716,315	4,417,693	.....	.....

Uses.—The three most important uses for lead are in the manufacture of white lead for the paint industry, which requires over 175,000 tons annually; in the manufacture of storage batteries, which absorbs over 150,000 tons of lead annually, and has increased between 50 and 100 per cent. per annum during the last three or four years; and in the manufacture of cables and conduits. The battery trade has been increasing rapidly in importance, due to wider application of storage batteries for starting and lighting purposes on automobiles, for mine-locomotives, for

[1] *Metal Ind.*, Jan., 1921.
U. S Geol. Surv.

the operation of small motors in industrial plants, and for farm lighting-plants.

IMPORTS OF LEAD, BY CLASSES, IN POUNDS

Year.	Lead in Ore (Lead Content).	Base Bullion.		Pigs, Bars, Sheets, and Old.	Total Lead Content.
		Gross Weight.	Lead Content.		
1912	19,577,499	152,420,624	146,999,168	544,925	167,121,592
1913	19,883,313	96,908,170	94,327,654	82,999	114,293,966
1914	23,649,637	33,444,503	32,730,320	296,846	56,676,803
1915	18,185,140	86,247,995	83,986,988	819,282	102,991,410
1916	35,086,100	24,943,660	24,262,435	11,310,817	70,659,352
1917	41,292,876	107,279,997	103,664,970	11,585,974	156,543,820
1918	37,070,340	155,810,003	149,663,889	10,480,531	197,214,760
1919	19,573,856	115,317,160	112,024,518	10,214,753	141,885,718
1920	29,488,816	101,476,550	96,103,603	71,457,108	197,029,527

IMPORTS OF LEAD, IN ORE, BASE BULLION, AND REFINED, BY COUNTRIES, IN POUNDS(a)

Country from which Imported.	1914.	1915.	1916.	1917.	1918.	1919.	1920.
United Kingdom.	245,548	185,236	261,406	2,689,992	56,710	.....	.....
Germany.....	4,529,919	.....	.....	.....	.....	.....	.....
Other European countries.	123,085	32,537	314,353	255,907	5,800	.....	.....
British North America .	384,007	2,303,170	12,606,216	11,738,379	28,255,878	10,327,531	7,832,583
Mexico.....	46,282,207	94,247,384	48,395,670	135,782,759	162,259,199	115,436,528	105,028,017
South America...	2,417,744	5,420,567	6,235,758	4,556,460	1,962,124	4,635,514	1,961,287
Other countries..	2,694,293	802,516	2,845,949	5,520,323	4,705,049	1,198,801	10,770,532
Total imports.	56,676,803	102,991,410	70,659,352	156,543,820	197,214,760	131,598,374	125,592,419

(a) Bureau of Foreign and Domestic Commerce.

Market.—To obtain a comprehensive view of the 1920 price movement in pig lead it is necesary to go back to Nov. 11 and 12, 1919, when the peak of the upward trend for 1919 apparently had been reached. The *Engineering and Mining Journal* quoted on these two days $6.85 per 100 lb., New York. By the first of December the New York price had declined $2 per ton, and the St. Louis price $4.50, and the domestic demand had greatly slackened. It was just at this period, however, that the position of the lead market changed completely. Although on Oct. 1 the London price was £25 12s. 6d., by Dec. 5 it had advanced to £40 per ton, and the market for lead had become a world market.

As the London price advanced, the Mexican production was sold in London instead of in New York, and the price in the latter city rose to a peak of 9.37½ cts. per lb. in March, and in August to a lower peak of 9 cts.

On March 11, the London price, translated into United States currency at the current rate of exchange, amounted to 8.35 cts. per lb. It was on this date that the long downward trend in London started, and the price steadily fell until in December, 1920, it reached 3.35 cts. per lb., a drop of 5 cts. per lb. during the nine months.

The price in the United States, after reaching its peak early in March, gradually followed the London price down, until July 10, when the active domestic demand not only advanced the price of New York, but also caused a marked strengthening of quotations in London. At this time, in a short period of two or three weeks, probably 20,000 tons of pig lead was bought for shipment to American consumers and distributors, and for the first time in years large lots of lead could be and were purchased for shipment to the United States from Mexico, England, Australia, France, Germany, and other countries at a price which, with duty and freight added, was less than the market ruling in New York.

During the second half of August, transportation in the United States improved markedly. Though at least 45,000 tons of pig lead was on the rails on Aug. 15, by Sept. 15 there was probably less than half this amount. It was just at this time that the great activity in the automotive industry stopped abruptly, and the storage-battery companies were obliged to reduce their orders for the immediate future by more than 50 per cent. and in some cases to cancel all shipments for a period of from 30 to 90 days.

The arrivals of pig lead in the United States during the first eight months of 1920 averaged less than 5600 long tons per month. In September, the reported arrivals were 17,195 long tons, and in October 10,760 long tons, an average monthly increase of over 8000 long tons.

In the face of adverse conditions in almost every lead-consuming industry, the New York price rapidly fell from 8.90 cts. per lb. on Sept. 8 to 4.50 cts. per lb. on Dec. 15, so that the close of the year ended the important post-war price movement which had lasted from May, 1919, to the end of 1920.

Although it may be true that the world price in the early months of 1920 was materially increased by speculation, many other important factors influenced the market. England imported from Spain, during the same first 10 months of 1920, about 36,000 gross tons, almost exactly the same amount as in 1919, but, during the first 4 months of 1920, imports from Spain aggregated 6700 long tons, as against 16,000 for the same period in 1919. The Australian production was greatly curtailed by strike conditions. During the first 10 months of 1920, England received slightly less than 50,000 long tons from Australia, as against 85,500 for the same period in 1919. The United States production was below normal, due largely to labor shortages in the mining districts. These conditions, combined with the congestion of transportation in the United States, were mainly responsible for the high prices during the first three quarters of 1920.

AVERAGE MONTHLY PRICE OF LEAD PER POUND IN NEW YORK (a)

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
1906...	5.600	5.464	5.350	5.404	5.685	5.750	5.750	5.750	5.750	5.750	5.750	5.900	5.657
1907...	6.000	6.000	6.000	6.000	6.000	5.760	5.288	5.250	4.813	4.750	4.376	3.658	5.325
1908...	3.691	3.725	3.838	3.993	4.253	4.466	4.477	4.580	4.515	4.351	4.330	4.213	4.200
1909...	4.175	4.018	3.986	4.168	4.287	4.350	4.321	4.363	4.342	4.341	4.370	4.560	4.273
1910...	4.700	4.613	4.459	4.376	4.315	4.343	4.404	4.400	4.400	4.400	4.442	4.500	4.446
1911..	4.483	4.440	4.394	4.412	4.373	4.435	4.499	4.500	4.485	4.265	4.298	4.450	4.426
1912..	4.435	4.026	4.073	4.200	4.194	4.392	4.720	4.569	5.048	5.071	4.615	4.303	4.471
1913..	4.321	4.325	4.327	4.381	4.342	4.325	4.353	4.624	4.698	4.402	4.293	4.047	4.370
1914..	4.111	4.048	3.970	3.810	3.900	3.900	3.891	3.875	3.828	3.528	3.683	3.800	3.862
1915..	3.729	3.827	4.053	4.221	4.274	5.932	5.659	4.656	4.610	4.600	5.155	5.355	4.673
1916..	5.921	6.246	7.136	7.630	7.463	6.936	6.352	6.244	6.810	7.000	7.042	7.513	6.858
1917..	7.626	8.636	9.199	9.288	10.207	11.171	10.710	10.594	8.680	6.710	6.249	6.374	8.787
1918..	6.782	6.973	7.201	6.772	6.818	7.611	8.033	8.050	8.050	8.050	8.050	6.564	7.413
1919..	5.432	5.057	5.226	4.982	5.018	5.340	5.626	5.798	6.108	6.487	6.808	7.231	5.759
1920...	8.561	8.814	9.145	8.902	8.576	8.323	8.338	8.687	8.177	7.070	6.159	4.727	7.957

(a) From *Eng. Min. Jour.*

AVERAGE MONTHLY PRICE OF LEAD PER 2240 LB. AT LONDON (a)
(In pounds sterling)

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1906....	16.850	16.031	15.922	15.959	16.725	16.813	16.525	17.109	18.266	19.350	19.281	19.609	17.370
1907....	19.828	19.531	19.703	19.975	19.688	20.188	20.350	19.063	19.775	18.531	17.281	14.500	19.034
1908....	14.469	14.250	13.975	13.469	12.938	12.600	13.000	13.375	13.125	13.375	13.538	13.156	13.439
1909....	13.113	13.313	13.438	13.297	13.225	13.031	12.563	12.475	12.781	13.175	13.047	13.125	13.042
1910....	13.650	13.328	13.063	12.641	12.550	12.688	12.531	12.513	12.582	13.091	13.217	13.197	12.920
1911....	13.009	13.043	13.122	12.889	12.984	13.260	13.530	14.260	14.744	15.332	15.821	15.648	13.970
1912....	15.597	15.738	15.997	16.331	16.509	17.588	18.544	19.655	22.292	20.630	18.193	18.069	17.929
1913....	17.114	16.550	15.977	17.597	18.923	20.226	20.038	20.406	20.648	20.302	19.934	17.798	18.743
1914....	19.665	19.606	19.651	18.225	18.503	19.411	19.051	(b)	(b)	(b)	18.500	19.097	.....
1915....	18.606	19.122	21.883	21.094	20.347	25.170	24.611	21.946	23.151	23.994	26.278	28.807	22.917
1916....	31.167	31.988	34.440	34.368	32.967	31.011	28.137	29.734	30.786	30.716	30.500	30.500	31.359
1917....	30.500	30.500	30.500	30.500	30.500	30.500	30.500	30.500	30.500	30.500	30.500	30.500	30.500
1918....	29.00	29.00	29.00	29.00	29.00	29.00	29.00	29.00	29.00	29.00	31.20	40.00	30.100
1919....	37.227	28.625	27.952	24.888	23.852	22.544	23.457	24.750	25.330	28.473	34.731	41.202	28.590
1920....	47.095	50.256	46.054	39.225	38.488	34.330	34.960	36.304	35.452	35.238	32.489	24.089	37.832

(a) The statistics for 1904–1905 are from the report of the Metallgesellschaft, Frankfurt-am-Main. Those for subsequent years are from the *Eng. Min. Jour.* (b) London exchange closed.

One of the interesting results of the heavy importations of pig lead was the change in the relationship between the New York and the St. Louis markets. The competition of foreign lead forced the New York price down to a level with the St. Louis price, so that the market for pig lead in cities in the Central Freight Association territory was higher than in New York City.

Consumption.—The peace-time demand for lead products has increased greatly since January, 1919. As heretofore, the paint industry has been the greatest outlet for pig lead, and most of the corroders enlarged their plants during 1920, in some cases by 100 per cent. The storage-battery industry was second in importance. The third largest demand came from the manufacturers of lead-incased cable. During the first half of the year, there was a fair-sized demand from manfacturers of sheet lead and lead pipe, and a large demand for sporting ammunition, bearing metals, solder, caulking lead, type metals, lead foil, and other commercial applications.

PRIMARY LEAD SMELTED OR REFINED IN THE UNITED STATES[1]
(Short tons) (Apportioned according to source of ore)[2]

	1912.	1913.	1914.	1915	1916.	1917.	1918.	1919.	1920.
Domestic Ore:									
Alaska	45	6	.....	358	659	884	531	645	.....
Arizona	3,891	4,901	5,602	6,953	15,328	7,456	6,195	5,407	7,000
Arkansas	.....	.....	52	51	170	300	14	.....	.....
California	811	3,294	3,698	5,606	3,633	11,471	6,228	2,004	2,536
Colorado	37,039	42,840	41,198	32,352	33,046	29,327	29,395	18,867	.....
Idaho	127,780	137,802	177,827	160,680	170,059	174,045	142,640	89,091	127,331
Illinois	513	619	427	910	670	867	1,010	977	.....
Iowa	.....	.....	34	.....	.....	.....	.....	.....	.....
Kansas	1,937	1,504	1,043	1,320	1,737	2,663	5,023	7,951	.....
Kentucky	91	16	16	95	37	21	109	83	.....
Missouri	162,610	152,430	194,275	195,634	218,253	218,197	187,743	150,341	.....
Montana	2,517	3,256	4,386	4,853	4,961	5,933	17,586	17,513	16,072
Nevada	5,699	6,142	5,996	7,664	11,858	12,334	8,726	5,958	9,755
New Mexico	2,511	1,821	741	2,157	3,290	3,428	5,140	1,418	.....
New York	.....	.....	.....	.....	.....	.....	49	.....	.....
North Carolina	34	10	.....	.....	.....	.....	.....	.....	.....
Oklahoma	2,500	3,214	3,916	4,346	10,969	19,646	58,755	49,984	.....
Oregon	21	37	17	11	9	.....	6	.....	.....
South Dakota	12	7	2	5	12	34	28	18	.....
Tennessee	.....	.....	.....	8	.....	.....	843	2,371	.....
Texas	30	108	89	111	26	58	30	8	.....
Utah	60,664	71,069	88,976	106,105	111,789	82,081	76,169	65,102	67,000
Virginia	85	878	143	457	740	147	59	.....	.....
Washington	53	9	2	11	217	929	906	1,090	2,540
Wisconsin	3,301	2,639	1,818	2,632	3,121	2,930	4,275	3,975	.....
Undistributed	120	63	99	131	159	145	59	119	.....
Zinc residues	3,131	3,765	4,125	4,567	5,478	6,489	5,359	4,887	.....
Total from domestic ore	415,395	436,430	534,982	537,012	596,221	579,385	556,878	427,825	483,000
Foreign Ore:									
Africa	1,774	5,976	2,942	.....	328	1,738	1,519	644	.....
Australia	.....	.....	.....	.....	.....	.....	282	69	.....
Canada	29	16	2	1,174	1,231	1,100	7,550	1,895	.....
Central America	.....	.....	.....	1	7	.....	.....	12	.....
Mexico	7,407	4,512	2,386	5,437	1,917	7,607	4,798	2,261	.....
South America	2,332	2,617	1,821	2,829	2,366	1,533	1,101	2,537	.....
Other foreign	30	102	488	140	236	3,894	84	238	.....
Foreign Base Bullion:									
Canada	.....	.....	.....	.....	1,072	6,750	8,108	567	.....
Mexico	76,805	37,359	21,689	33,173	11,598	39,508	76,809	49,564	.....
South America	.....	.....	.....	275	151	189	39	.....	.....
Total from foreign ore and base bullion.	88,377	50,582	29,328	43,029	18,906	62,319	100,290	57,787	64,000
Grand total, derived from all sources.	503,772	487,012	563,810	580,041	615,127	635,669	657,168	485,612	547,000

[1] These figures include the lead derived from scrap and junk by primary smelters.
[2] U. S. Geol. Survey, except 1919 and 1920, which are Survey figures for mine outputs.

The three most important industries undoubtedly consumed a tonnage of lead in 1920 equal to the entire domestic production in the United States. That a greater shortage of lead did not occur was due to the heavy importation of lead and to the extraordinary tonnage of reclaimed lead made available.

In 1920, it is probable that over 150,000 tons of secondary lead was made available for consumption, the increase being attributable in a large measure to the heavy tonnage of shrapnel balls, small-arms ammunition, and sheet lead which was reclaimed by the United States and other countries and shipped to the market in New York, where it could be paid for in dollar exchange.

Secondary Lead[1]

The secondary lead recovered in 1919 amounted to 122,100 short tons, or about 25,000 tons more than in 1918. The secondary lead recovered as pig lead increased about 14,500 tons, and the secondary pig lead recovered by those smelters whose product is mainly primary metal was 5269 tons more in 1919 than it was in 1918. The quantity of secondary lead recovered in alloys increased from 55,954 tons in 1918 to 66,416 tons in 1919, so that the increase in secondary lead was due mainly to the larger quantity of lead and of alloys containing lead treated by smelters which treat scrap and drosses only. A portion of the recovered lead in alloys was derived from old babbitt, solder, type-metal, and white-metal drosses. The main sources of secondary pig lead are old pipe, lead cable, battery-plates, and lead lining of acid-tanks. Regular smelters reported the recovery of 2154 tons of lead in scrap antimonial lead. It is stated that the manufacturers of toys formerly imported from Europe consume a large quantity of impure and very low-grade lead scrap.

The quantity of scrap antimonial lead remelted by regular smelters was 9 per cent. less than that reported in 1918.

The use of lead in batteries has expanded rapidly with the increase in the automotive industry, and a large part of the secondary lead now recovered is obtained from old batteries. The life of a lead battery is comparatively short, and large quantities of battery lead plates are recovered at secondary smelters.

The total output of secondary lead was equal to about 25.3 per cent. of the refined primary lead produced in the United States in 1919, compared with 15.2 per cent. in 1918. It was exceeded by the output of primary domestic lead in only two States—Missouri and Idaho.

SECONDARY LEAD RECOVERED

	1919, Short Tons.	1920, Short Tons.
Secondary lead recovered by smelters that treat mainly ores	12,545	12,787
Secondary lead recovered by plants that treat only scrap and drosses	43,139	43,563
	55,684	56,350
Secondary lead recovered in remelted alloys:		
Lead content of antimonial lead scrap treated at regular lead smelters	2,156	2,687
Lead content of drosses and scrap alloys treated at secondary smelters	64,260	65,613
Total lead in alloys	66,416	68,300
Total secondary lead recovered	122,100	124,650

Lead Pigments

The accompanying table shows the quantity and value of lead pigments of domestic manufacture sold in the United States according to figures compiled by the United States Geological Survey.

[1] J. P. Dunlop, *Min. Res. U. S.*, 1919, Part I, and 1920, preliminary statement.

PRODUCTION OF LEAD PIGMENTS IN THE UNITED STATES

Year.	Red Lead.		White Lead. (a)		Litharge.		Orange Mineral.	
	Short Tons.	Value.	Short Tons.	Value.	Short Tons.	Value.	Short Tons.	Value.
1905...	16,269	1,919,767	122,398	12,068,443	12,643	1,422,616	1,000	120,000
1906...	13,693	1,874,448	123,640	15,234,990	13,816	1,890,050	2,927	421,488
1907...	13,370	1,778,717	111,409	12,254,297	14,769	1,624,553	815	123,917
1908...	11,358	1,156,282	116,628	10,515,315	12,254	1,231,206	393	43,157
1909...	15,800	1,438,197	131,643	12,652,638	13,391	1,266,903	530	68,003
1910 (b)	16,116	1,482,672	134,276	13,024,762	13,659	1,283,940	541	70,335
1911 (b)	19,594	2,345,520	132,612	17,393,241	25,190	2,733,196	766	119,370
1912 (b)	21,120	2,571,702	146,833	18,683,461	29,111	3,194,194	545	88,240
1913 (b)	17,635	2,127,976	142,626	18,112,219	23,093	2,524,707	434	71,625
1914 (b)	18,697	2,151,054	159,474	19,943,239	27,345	2,856,092	426	70,019
1915 (b)	19,435	2,397,900	156,101	19,393,691	26,118	2,822,415	.....	.....
1916 (b)	23,035	3,933,566	128,979	21,274,480	37,739	5,853,543	(c)	(c)
1917 (b)	25,478	5,525,018	115,200	22,529,831	44,102	8,611,074	(c)	(c)
1918 (b)	30,069	5,928,597	102,888	20,766,848	48,874	8,825,724	(c)	(c)
1919 (b)	32,362	5,314,255	139,090	26,425,022	46,739	6,431,801	(c)	(c)
1920 (b)	34,431	7,523,089	145,695	32,337,898	62,329	12,386,185	(c)	(c)

(a) The output of "sublimed white lead," a mixed sulphate and oxide of lead, is not included in 1905–1910. (b) U. S. Geol. Surv. (c) Orange mineral included in red lead.

IMPORTS OF LEAD PIGMENTS INTO THE UNITED STATES

Year.	Red Lead.		White Lead.		Litharge.		Orange Mineral.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1904.....	836,077	$30,115	587,383	$33,788	44,541	$1,500	766,469	$37,178
1905.....	704,402	26,553	597,510	34,722	117,759	4,139	628,003	31,106
1906.....	1,093,619	50,741	647,636	41,233	87,230	3,737	770,342	42,519
1907.....	679,171	35,959	584,309	37,482	90,475	4,386	615,015	37,799
1908.....	645,073	28,155	540,311	30,451	96,184	3,327	485,407	26,645
1909.....	760,179	30,428	694,599	39,963	90,655	3,740	496,231	27,562
1910.....	822,289	32,750	686,052	38,919	48,693	2,252	600,461	32,199
1911.....	1,163,533	46,170	741,071	46,213	24,662	1,196	504,734	28,515
1912.....	757,908	33,854	687,705	46,494	32,443	1,550	334,551	20,914
1913.....	99,832	4,903	672,109	45,266	34,023	1,750	330,525	22,205
1914.....	13,554	2,907	596,567	40,213	33,651	1,805	240,388	16,388
1915.....	1,968	142	239,187	24,608	20,650	1,422	171,572	14,061
1916.....	20,467	5,302	88,617	8,050	1,320	150	70,934	8,781
1917	50	13	20,238	1,965	*Nil.*	*Nil.*	33,294	4,892
1918.....	5	1	158	131	100	12	*Nil.*	*Nil.*
1919.....	7,199	1,136	21,213	2,490	*Nil.*	*Nil.*	39,781	5,081

Four companies control the manufacture of 95 per cent. of the white lead made in the United States and fix prices through the American Institute of Lead Manufacturers, according to evidence placed on Dec. 23 before a committee in New York that has been investigating building-trade conditions. These are the National Lead Co., the Eagle Picher Co., of Chicago, the Sherwin Williams Paint Co. and the du Pont de Nemours company, of Wilmington, Del. According to reliable reports of the hearings in the daily press, prices were fixed through the medium of the National Lead Co., which is said to have acted as pacemaker, and which notified the institute of changes. According to the testimony, the price of white lead has risen from 6 cts. a lb. in 1916 to as high as 15½ cts. last month. The sales of this material by the National Lead Co. alone amounted to over $21,000,000 in 11 months of 1920.[1]

[1] *Eng. Min. Jour.*, Jan. 1, 1921.

Anaconda Lead Products Co.—The electrolytic white lead plant, located at East Chicago, Ind., was put in operation on Jan. 25, 1920, and immediately, as is usually the case in new-process work, weaknesses in equipment and plant design developed, which from time to time were remedied and will be completely overcome in the near future.

The cell-room of the plant developed a greater tonnage than was anticipated, thereby throwing out of balance the filtering, drying, and barreling department.

The process operated satisfactorily, the grade of the product being excellent, establishing a new standard of whiteness for white lead. Construction and operation of the plant was seriously hampered by a scarcity of labor, which was remedied only toward the close of the year.

The plant made an output of 18 tons of white lead per day during the last month of the year.[1]

Lead Mining in the United States

The following reports, except where otherwise noted, are from the U. S. Geological Survey.

Alaska.—Alaska produced about 880 tons of lead in 1920; it was valued at $142,000. The increase in lead output from 564 tons in 1919 to 880 tons in 1920 was from galena ores mined in a small way at several localities. The largest shipment of galena ore was made by a small mine in the Kantishna district.

Arizona.—The mine production of lead in Arizona increased from 10,203,078 lb. in 1919 to about 14,350,000 lb. in 1920. The value of the output increased from $540,763 to about $1,148,000. Most of the shipments of lead ore were made from the Shattuck mine, in the Warren district; other producers were the Bunker Hill, at Tombstone, Kingman Consolidated, in Mohave County, the Aravaipa Leasing Co., in Graham County, and several properties in Santa Cruz County.

The recoverable lead production in 1920, by counties, is given as follows:

	Pounds
Cochise	9,549,906
Gila	1,650,427
Graham	268,477
Maricopa	75,733
Mohave	513,902
Pima	209,989
Pinal	129,254
Santa Cruz	1,581,499
Yavapai	238,296
Yuma	382,282
Total	14,599,765

[1] Anaconda Copper Min. Co., Annual Rept.

California.—The estimated output of lead in 1920 is 4,813,510 lb., an increase of 1,345,243 lb. over the output in 1919. This increase is due entirely to the production of one mine in southern California that reported no output in 1919. Moreover, a number of lead and silver-lead properties, mainly in San Bernardino and Inyo counties, began or increased production in 1920. Nevertheless the output of lead in California is still far below the normal, as that in 1918 was over 13,000,000 lb.

Colorado.—The Ohio & Colorado smelter at Salida, Colo., closed early in 1920, was sold later in the year to a company which will operate it in connection with the Rawley mine at Bonanza, Colo., when conditions are more favorable.

The recoverable lead production in 1920, by counties, is given as follows:

	Pounds
Boulder	226,825
Chaffee	399,123
Clear Creek	3,284,612
Custer	171,560
Dolores	757,052
Eagle	292,528
Gilpin	438,289
Grand	528
Gunnison	852,080
Hinsdale	79,690
Lake	9,543,758
La Plata	949
Mineral	531,536
Ouray	1,302,681
Park	1,085,665
Pitkin	4,490,648
Saguache	160,140
SanJuan	14,741,907
San Miguel	7,550,027
Summit	448,217
Teller	25,210
Total	45,383,025

Idaho.—The mine output of lead, which is the most abundant metal in Idaho, increased from 182,341,898 lb. in 1919 to nearly 250,000,000 lb. in 1920. The average price of lead was higher, and the value of the output increased from $9,664,121 to about $19,969,000. Though the total production shows a great improvement over that of 1919, the mines have not generally returned to a normal output. In 1920, as in past years, the Bunker Hill mine produced much more lead than any other property. Six other mines each produced more than 10,000,000 lb. of lead—the

Hercules, Hecla, Morning, Consolidated Interstate, Tamarack & Custer, and Gold Hunter mines. The Coeur d'Alene district alone produced about 242,000,000 lb. of lead. Large quantities of lead ore and concentrate were also shipped from the Idaho Continental, Pittsburgh-Idaho, Latest Out, and Independence mines, near Ketchum, in Blaine County.[1]

The lead production in 1920, by counties, was as follows:

	Pounds
Blaine	2,149,593
Boise	1,650
Bonner	2,307
Boundary	3,429,540
Butte	144
Camas	6,319
Custer	1,932,088
Gem	879
Lemhi	5,876,375
Owyhee	780
Shoshone	236,310,301
Total	249,609,976

The State Mine Inspector reports the following lead production for Idaho since 1898:

1898	122,479,275
1899	86,499,506
1900	96,425,500
1901	65,967,000
1902	119,223,000
1903	220,857,956
1904	226,261,728
1905	260,791,456
1906	255,966,083
1907	234,404,920
1908	207,998,499
1909	217,594,679
1910	239,144,570
1911	274,492,873
1912	296,054,813
1913	318,377,280
1914	345,334,106
1915	369,242,000
1916	366,594,000
1917	395,883,000
1918	290,848,425
1919	182,341,898
1920	249,609,976

Missouri.—The pig-lead output of the Southeastern or disseminated lead belt in 1920 was about 158,000 tons (December production estimated). This is about 3 per cent. greater than 1919, but is about 20 per cent. below the record year of 1917, when lead reached the peak price of 12 cts., as the result of war conditions. Had there not been a continuous shortage of labor throughout 1920, the output would have been considerably larger, despite decreased efficiency.

The year 1920 was marked by violent changes in the lead market.

[1] U. S. Geol. Surv.

Labor was paid the maximum war rates throughout the year, but beginning Jan. 1, 1921, a reduction of 20 per cent. was made where the wage exceeded $4 per day, and 9 per cent. upon less than $4, with a minimum of $3. In the Joplin district, which experienced low prices for zinc ore, a horizontal reduction of $1 per day has been made recently.

Several shafts and two mills have been shut down in St. Francois County, which produced almost the entire output in 1920. The Missouri Cobalt Co., in Madison County, closed its plant in October. A small amount of lead is produced by this company as a by-product from four to five tons of copper and about three tons of nickel and cobalt products per day from the former North American property at Fredericktown. The St. Joe company found a new orebody two miles west of Leadwood, and is sinking a new shaft on the old Donnelly tract in Flat River. It is also erecting an additional electric power plant at Rivermines, which will enable the entire property to be operated by electricity. Its Crawley, or No. 8, shaft will connect underground with the 6,000-ton mill of the former Doe Run plant, thus supplying this mill entirely through mine haulage and doing away with surface transportation over the M. R. & B. T. R.R. The old Mine la Motte property, in Madison County, remains closed down through litigation, and no lead is being produced in the county. The Picher Lead Co. has optioned the Schulte tract, near Fredericktown, and is doing additional diamond drilling. The Einstein tungsten property, on the St. Francois River, remains closed, but some prospecting for tungsten in the granite is being carried on in the neighborhood. In the neighboring counties of Washington, Franklin, and Jefferson only small amounts of lead were produced from shallow "diggings" in 1920, with no attempt to prospect for the deep disseminated lead.[1]

LEAD ORE PRICES IN THE JOPLIN DISTRICT
(Per ton of 2000 lb.)

	Past Years.		1920.	
	High.	Average.		
1908	$ 66.00	$54.66	January	$ 94.39
1909	60.50	54.56	February	85.33
1910	58.00	51.98	March	102.18
1911	64.00	56.76	April	107.09
1912	68.00	56.60	May	105.67
1913	58.00	52.52	June	101.93
1914	54.50	46.55	July	98.85
1915	80.00	55.08	August	101.35
1916	104.84	84.07	September	101.99
1917	135.50	98.00	October	90.05
1918	106.00	88.98	November	84.67
1919	89.00	66.20	December	70.00
1920	112.50	95.71		
			Year	$95.71

[1] H. A. Wheeler, *Eng. Min. Jour.*, Jan. 22, 1921.

Montana.—The mine production of lead decreased from 34,437,764 lb. in 1919 to about 31,250,000 lb. in 1920, but the value of the output increased from $1,825,201 to about $2,500,000, as the average price of lead was higher. Most of the lead was obtained in the treatment of lead-zinc ores of the Anaconda Co., Butte & Superior, Elm Orlu, and Butte Copper & Zinc Co., at Butte, and the Snow Storm, at Troy, Mont. Other large producers were the Cascade Silver property, at Neihart, the Angelica, near Wickes, and the Comet and Crystal mines, near Basin. Much lead was also recovered by smelting material from old slag dumps. The smelting plant of the American Smelting & Refining Co., at East Helena, was active in 1920 and increased its output of lead bullion.

Early in the year one of the former copper blast-furnaces at the Great Falls plant of the Anaconda Copper Mining Co. was remodeled for the smelting of the leady residues from the zinc leaching plant.

The furnace smelted 200 tons of charge per 24 hours with about 12 per cent. lead-fall and made a rich silver-lead bullion. The zinc-plant residue and bag-house fume was briquetted before charging into the furnace.

The Montana lead production in 1920, by counties, is given as follows:

	Pounds
Beaverhead	1,968,009
Broadwater	401,551
Cascade	3,127,148
Fergus	358
Granite	76,033
Jefferson	3,414,357
Lewis and Clark	829,987
Lincoln	3,328,265
Madison	287,408
Mineral	43,848
Park	95,680
Powell	88,721
Silver Bow	17,590,182
Toole	2,369
Total	31,253,916

Nevada.—The mine output of lead increased in quantity from 15,349,370 lb. in 1919 to about 21,260,000 lb. in 1920 and in value from $813,517 to about $1,701,000. The Prince Consolidated mine, at Pioche, and the Yellow Pine mine, in Clark County, were the largest lead producers of the State. There was much activity in the mines near Pioche and a greater production from the Virginia Louise, Black Metals, Bristol Silver, and Combined Metals. Other large producers were the Spruce Monarch, in Elko County, Eureka Holly and Eureka Croesus, at Eureka,

Nevada United, in White Pine County, and the Louisiana Consolidated, in Nye County, where a new lead smelter was operated for a short time. Near Arden in Clark County, a body of lead ore was opened in the Potosi mine, formerly a large producer of zinc.

The Nevada lead production in 1920, by counties, is given as follows:

	Pounds
Churchill	12,659
Clark	4,018,864
Elko	3,353,164
Esmeralda	95,743
Eureka	2,487,210
Humbolt	28,034
Lander	262,045
Lincoln	7,904,470
Mineral	158,555
Nye	633,227
Pershing	101,298
Washoe	85,172
White Pine	2,123,259
Total	21,263,700

New Mexico.—Lead ore was shipped from the Organ Mountains, Dona Ana County, from the Central district, Grant County, from the Magdalena district, Socorro County, and from the Victorio district, Luna County.

Utah.—The mine output of lead increased from 123,829,051 lb. in 1919 to about 141,000,000 lb. in 1920. The value of the output increased from $6,562,940 to about $11,267,000. The largest producers of lead in the State were the Utah Apex, United States Mining Co., Tintic Standard, Chief Consolidated, Utah Consolidated, Silver King Coalition, Daly Judge, Ophir Hill, and Eagle & Blue mines. The largest increases were those of the Chief Consolidated and Tintic Standard, in the Tintic district.

The Utah lead production in 1920, by counties, is given as follows:

	Pounds
Beaver	2,808,314
Box Elder	18,130
Juab	27,902,353
Piute	859,753
Salt Lake	59,162,056
Summit	18,220,550
Tooele	10,272,259
Utah	14,083,144
Wasatch	7,511,554
Total	140,838,113

Washington.—The mine output of lead increased from 2,146,157 lb. in 1919 to a total of 5,787,247 lb. in 1920, and the value from $113,746 to about $463,000. Most of the product came from the Electric Point property, near Northport, in Stevens County, the shipments from which were greatly increased. In the same district much lead ore was opened in the Gladstone mine, from which several shipments were made during the year.

LEAD PRODUCTION OF THE WORLD
(In metric tons)

Year	Australasia. (a)	Austria. (a)	Belgium. (g)	Burma. (a)	Canada. (a)	France. (a)	Germany. (a)	Greece. (a)	Hungary. (a)
1905	106,418	12,968	22,885	.....	25,391	24,100	152,590	13,729	2,146
1906	93,557	14,846	23,765	.....	24,580	25,614	150,741	12,308	1,925
1907	96,608	13,598	27,450	.....	21,660	24,800	164,079	13,814	1,468
1908	119,207	12,669	35,650	.....	19,593	26,112	164,079	15,892	1,544
1909	77,992	12,941	40,306	.....	23,295	26,927	167,920	14,948	1,590
1910	105,897	15,476	40,715	.....	14,967	20,226	159,851	16,710	2,077
1911	105,397	18,097	44,308	.....	10,791	23,635	161,287	14,234	1,583
1912	113,710	19,993	54,940	.....	16,226	31,080	192,618	14,498	1,605
1913	110,444	1,368	53,590	5,951	17,089	28,817	181,100	18,309	(e)1,790
1914	101,788	755	45,560	10,717	16,487	29,601	198,450	20,684	1,368
1915	102,721	.....	16,770	13,758	19,740	14,539	134,750	11,595	.....
1916	134,072	.....	15,560	14,011	19,879	24,276	.....	9,424	.....
1917	144,950	783	22,745	17,233	20,709	21,235	.....	1,422	.....
1918	163,368	.....	20,630	19,380	17,005	12,778	.....	.....	.....
1919	83,404	.....	4,225	19,396	16,143	10,928	.....	3,841	.....
1920	7,802	(i)1,800	16,040	24,198	13,733	.....	(i)54,400	(i)4,000	.....

Year.	Italy. (a)	Japan. (a)	Mexico. (a)	Spain. (a)	Sweden. (a)	United Kingdom. (a)		United States.	Totals. (f)
						Foreign Ores.	Domestic Ore.		
1905....	19,097	2,272	(b)101,196	185,693	576	7,517	20,977	290,472	988,727
1906....	21,268	4,305	(b) 73,699	185,470	753	6,984	22,691	323,567	986,980
1907....	22,978	3,067	(b) 76,158	(d)185,800	813	10,880	24,850	322,854	1,011,397
1908....	26,003	2,910	(b)127,010	188,062	277	11,480	21,336	284,858	1,057,205
1909....	22,133	3,429	(b)118,186	179,993	166	8,056	22,822	329,690	1,056,326
1910....	14,495	3,907	(b)120,662	190,523	355	8,933	21,866	353,186	1,093,043
1911....	16,684	4,160	(b)124,605	189,810	1,134	10,048	18,279	368,301	1,108,880
1912....	21,450	3,613	(b)109,717	232,612	1,073	(e) 8,255	19,473	376,947	1,212,252
1913....	21,674	3,777	(d) 41,569	198,829	1,235	.....	18,462	396,034	1,142,264
1914....	20,464	4,563	(d) 14,853	143,524	1,396	.....	19,684	485,011	1,128,000
1915....	21,812	4,764	(d) 38,319	171,472	1,918	.....	15,767	487,177	‡1,038,000
1916....	24,362	11,343	(d) 13,332	147,407	2,076	.....	12,775	540,892	.....
1917....	16,237	15,807	(d) 50,212	172,909	3,174	.....	11,431	(g)527,729	.....
1918....	18,332	10,769	(d) 69,035	169,709	2,241	.....	11,269	(g)504,614	.....
1919....	16,530	5,771	(d) 54,932	125,721	827	.....	11,458	(g)412,704	.....
1920 ...	15,915	(i)5,000	(d) 54,536	(i)142,000	.....	.....	.....	(g)427,966	.....

(a) From official reports of countries unless otherwise denoted. (b) Exports. (d) U. S. imports. (e) Estimated. (f) The totals may be high on account of duplications which cannot be eliminated. (g) From *Eng. Min. Jour.* (h) Production of pig lead in Mexico. Lead smelted from Mexican ore in the United States is not included either under Mexico or the United States. (i) Am. Bur. Metal Stat.

LEAD IN FOREIGN COUNTRIES

Australia.—A relatively large proportion of the Australian production of lead, zinc, and silver is produced by the various mines at Broken Hill, New South Wales, all of which is handled through the State of South Australia. The lead and zinc is treated at Port Pirie by a producers' association which owns the reduction plant there.

The strike at Broken Hill was finally settled in November, but some time must elapse before the mines and smelters there can get into effective operation.[1]

Canada.[2]—The production of lead in 1920 amounted to 33,985,974 lb. valued at $3,038,346, or an average of 8.940 cts. per lb., as against 43,827,699 lb. valued at $3,053,037, or an average of 6.966 cts. per lb. in 1919, showing a decrease of 21.9 per cent. in quantity, and 0.5 per cent. in value. The values are calculated on the average price of lead in Montreal.

The production includes 28,985,590 lb. of refined lead and pig lead produced in Canada from the treatment of the Canadian ores, together with 5,000,384 lb. of lead being estimated as recovered from ores exported to the United States.

The lead ores exported were derived mostly from the mines of East and West Kootenay, B.C., supplemented by shipments from Notre Dame des Anges, Quebec.

The total shipments from the mines of lead ores and concentrates were about 66,956 tons, containing approximately 33,802,270 lb. of lead.

The record of lead contents of ores and concentrates shipped and recoveries in smelters from domestic and imported ores are presented for comparison, together with a record of pig and refined lead produced.

	1917 Pounds.	1918 Pounds.	1919 Pounds.	1920 Pounds.
(1) Lead contents of ores and concentrates shipped from mines in Canada	38,696,116	46,843,602	32,147,989	33,802,270
(2) Production: Smelter recoveries from Canadian ores and recoverable lead in ore exported	32,576,281	51,398,002	43,827,699	33,985,974
(3) Total production of refined lead in Canada (including lead from imported ores)	32,115,114	31,571,112	34,330,920	28,720,030

The exports of lead in 1920 were: Lead contained in ores, concentrates, etc., 7,549,400 lb., valued at $385,839, and pig lead, 18,800 lb. valued at $1,846. The exports in 1919 were: Lead in ores, etc., 13,142,900 lb., valued at $616,278, and pig lead 11,326,800 lb., valued at $772,734.

The imports of lead in 1920 were valued at $2,987,467 and contained approximately 16,000 tons of lead, as against a total value of $1,022,265 and an approximate lead content of 7044 tons in 1919.

The average price of lead in Montreal was 9.93 cts. per lb. in January and increased to a maximum of about 11 cts. in March, then gradually declined to an average of 5.94 cts. for December.

[1] U. S. Geol. Surv.
[2] Prelim. Rept., Min. Prod. of Canada, 1920, Can. Dept. Mines.

Japan.[1]—The quantity and value of the annual production of lead in Japan from 1913 to 1918 is given as follows:

Years.	Pounds.	Value.	Years.	Pounds.	Value.
1913	8,393,138	$308,006	1916	25,268,685	$1,872,332
1914	10,138,205	412,400	1917	35,127,077	2,822,018
1915	10,567,457	486,729	1918	23,742,236	2,070,266

Imports of lead and lead ore into Japan from 1915 to 1919 are stated as follows:

Years.	Lead Ore.		Lead Ingots and Slabs.		Other.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1915	(a)	(a)	32,279,973	$1,450,656	2,872,805	$175,860
1916	(a)	(a)	46,230,232	3,720,089	3,460,964	278,704
1917	50,520,532	$1,253,759	35,024,068	2,926,798	1,567,652	144,154
1918	7,989,466	191,130	120,283,002	7,351,379	1,447,808	153,538
1919	330,667	8,007	79,607,814	5,432,046	(b)	(b)

(a) Not known. (b) Statistics not yet available.

Mexico.—The lead smelters at Aguascalientes, Torreon, San Luis Potosi, Saltillo, and Monterey were closed during 1920.[2] Mexico's smelter production of lead in 1920 is given as 119,482 tons.

Spain.—Spain has a small domestic consumption, and exports most of her lead ores and smelter production, while, as over half the Spanish output is controlled by French capital, and the remainder to a large extent by English interests, Spanish lead finds a market chiefly in satisfying the wants of France and England. Labor troubles have greatly interfered with the supply of Spanish lead available for foreign markets.[3]

Messages from Cartagena report a serious crisis in the mining industry of that district, one of the most important lead-producing regions of Spain. A thousand miners are said to have already been dismissed, owing to the fall in the price of lead ore on the foreign markets. In reality the fall in price has only aggravated a local crisis, which has existed in the region for the last three years, the causes of which are set forth in a report to the Ministerio de Fomento, as follows: The general impoverishment of the mines; the exorbitant rents paid by the working concerns; the high prices for all kinds of material; the increase in the price of explosives; the insufficient hydro-electric power available. Experts are of the opinion that the known veins are becoming exhausted, and that a gradual cessation of activity will be unavoidable unless new veins are discovered.[4]

[1] *Comm. Rept.* [2] *Metal Bull.* [3] *Metal Bull.*, June, 1920. [4] *Min. Jour.*

SPANISH EXPORTS[1]

Silver Lead

To	1917.	1918.	1919.
Belgium	.....	.....	300
France	464	227	3,319
Great Britain	20,239	14,937	17,678
Holland	.....	.....	.....
Other countries	715	1,198	.....
Total	21,418	16,362	21,297

Soft Lead

To	1917.	1918.	1919.
Belgium	.....	.....	14,420
France	46,649	39,858	48,381
Great Britain	44,845	34,792	16,377
Holland	926	.....	1,959
Italy	27,036	47,180	3,705
Portugal	1,253	3,166	638
Other countries	12,751	2,415	1,960
Total	133,460	127,411	87,404

The Société Miniere et Metallurgique de Penarroya reports two dividends paid during 1920, one for 3,656,250 fr. and an additional one of 8,043,750 fr. Galena and lead produced were as follows:

	1919. Tons.	1920. Tons.
Galena	59,950	54,697
Lead	73,803	75,509

Labor conditions were highly unsettled in the Penarroya and Puertollano districts. The cost of labor was increased and government regulations added to the cost of production.[2]

The owners of the El Guindo lead mine in Spain, one of the oldest and richest mines in the Jaen district, have acquired an extensive site near Malaga upon which they will put up a smelter. Work is to be commenced at once. Spanish and German capital are interested in the company.[3]

United Kingdom.—There has been a remarkable fluctuation in the balance of lead available for home consumption in the United Kingdom during recent years. During 1913 the excess of imports over exports was 141,793 tons, in 1914 it was 173,857 tons, in 1915 188,530 tons, in 1916 123,713 tons, in 1917 137,673 tons, in 1918 204,022 tons, in 1919 181,237 tons and last year only 101,077 tons. Prior to the war there were no figures available as to the stocks in this country, so that, assuming the stocks to be constant (which, of course, they are not), the home consumption would have been represented by the balance of supplies plus the production from our home mines, which was never very important, but averaged some 12,000 tons or thereabouts a year. Based only upon the balance of imports, however, the quantities available for home consumption during 1912 were 146,741 tons, during 1913 142,143 tons, and during 1914 170,210 tons.

With the issuing of stock returns after the war, however, a closer approximation became possible. The stock at the end of 1918 was re-

[1] *Metal Bull.*, Jan., 1921. [2] *Echo des Mines*, June 10, 1921. [3] *Metal Bull.*, May, 31, 1921.

turned at 62,852 tons, and at the end of 1919 at 54,975 tons, a decrease of 7,877 tons. Allowing for this decrease the apparent consumption in 1919, exclusive of lead from home-produced ores, was 189,114 tons, and in 1920 (when the stock reduction was apparently 35,930 tons) 137,007 tons. At best the calculation can only be roughly approximate, but it should serve as some sort of basis for comparison.[1]

UNITED KINGDOM LEAD EXPORTS
(In Long Tons)

	1919.		1920.	
	English.	Foreign.	English.	Foreign.
January	1,042	.....	2,631	2,048
February	596	.....	2,707	2,904
March	1,252	.....	3,987	3,540
April	1,030	203	2,651	2,259
May	1,023	229	2,366	951
June	1,073	132	2,508	1,172
July	1,854	220	3,855	105
August	4,091	700	3,428	1,679
September	2,145	1,114	3,841	5,025
October	4,222	3,181	3,146	3,937
November	3,298	2,576	2,069	1,865
December	3,944	2,449	1,439	1,660
Total	25,570	10,803	34,628	27,145

UNITED KINGDOM LEAD IMPORTS

From	1918.	1919.	1920.
Spain	49,977	39,502	58,149
U. S. A.	61,576	53,008	9,756
Mexico	.....	2,114	1,049
Australia	85,280	93,276	57,987
Elsewhere	11,099	29,710	35,909
	207,932	217,610	162,850

Under the name of Associated Lead Manufacturers, Ltd., a company was registered some time ago, and is now about to come into actual operation. It acquires control of the following firms:

H. J. Enthoven & Sons, Ltd.
Walkers Parker & Co., Ltd.
Locke, Lancaster & Co. and
W. W. & R. Johnson & Sons, Ltd.
James & Co., Ltd.
Foster, Blackett & Wilson, Ltd.
Alexander, Fergusson & Co., Ltd.

The new combine will be closely associated with the Burma Corporation.[2]

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[1] *Metal Bull.*, Feb. 21, 1921.

[2] *Metal Bull.*, Feb. 1, 1921.

Metallurgy of Lead in 1920

By J. Labarthe

Improvements in the Art of Lead Smelting and Refining

Use of Pulverized Coal.—Pulverized coal on lead blast-furnaces has been developed with more or less satisfactory results at the Midvale plant of the United States Smelting, Refining & Mining Co. near Salt Lake City. A specially designed distributing system for the pulverized coal and a special tuyere are important factors in the success of this application. Both the distributing system and the tuyere are different from those illustrated and described by Mr. Wotherspoon in his article on "Progress in Powdered Coal for Blast-furnaces" as published in the *Engineering and Mining Journal* of Apr. 3, 1920.

Pulverized coal in the proper pre-determined quantity is fed by gravity to a light sheet-iron hopper attached to a pipe which enters and extends through the tuyere-box cover. The coal is forced through the tuyere-box and into the furnaces by the injector principle. An air-blast of about 15 lb. pressure is maintained. This apparatus has been quite successful and it has been possible to replace about 30 per cent. of the fuel requirements by means of powdered coal. The tonnage smelted has been somewhat less on the coal-fired furnaces, but there has been no trouble in maintaining hot slag and hot lead, and the general furnace conditions and reduction have been good.

Powdered coal is used as fuel for igniting the charge on Dwight-Lloyd machines at both Midvale, Utah, and at Kellogg, Idaho. The application at these plants is quite different. At Midvale, coal is fed into a small hopper, near the burner, by gravity and delivered through the burner by the injector principle with an air-blast of approximately 6 oz.

At the Bunker Hill plant, at Kellogg, coal is delivered directly to the burners by the Holbeck system. The regulation of supply is governed by a valve in the main coal-line where the pulverized coal is carried continuously by air in the proportion of 1 lb. of coal to 50 cu. ft. of air, with from 10 to 15 oz. pressure.

At the Bunker Hill smelter, the lead refining furnaces and equipment are fired by pulverized coal.

Screening.—In the crushing and sampling departments of several Western smelters, vibrating screens have replaced the old style trommel. This change has resulted in great economy in operation, greater capacity and more uniform product.

Roasting.—In the Dwight-Lloyd roasting departments of the various Western plants, numerous improvements have been made, particularly in the type of grate-bar used in connection with these machines.

At the Bunker Hill smelter, at Kellogg, an improvement has been made in the Stewart or Trail type of grate-bar, whereby the central moveable member is held in position so as to insure a uniform opening at all points and at the same time allow the rocking movement, which causes the dislodging of slagged material and insures clean grates without manual or other mechanical cleaning. Another improvement in the feeding of the Dwight-Lloyd machines at Kellogg has resulted in the use of a revolving cylinder mixer in place of the pug-mill type mixer and also an oscillating spout which delivers the mixed material back and forth across the width of the machine. This spout has prevented the segregation of various parts of the charge and resulted in more satisfactory product from the machine.

At the Midvale plant of the United States Smelting and Refining Co. a change was made in the Stewart grate-bar wherein the surface of the moveable portion of the bar is made convex. This has a tendency to deliver the coarse particles of the charge over the openings and results in a more porous charge and prevents an undue amount of fines escaping into the wind-box.

Fume Recovery.—The use of the Cottrell fume-precipitating apparatus has become quite general in Western lead smelters. At some plants, the installation is used for collecting values contained in roaster gases only, while at other plants, blast-furnace gases, as well as roaster gases, are passed through the treater. In some installations where mixed gases are treated, their basic character has caused difficulty in obtaining good clearance or results approaching perfect precipitation. This has been largely overcome by humidifying the gases by means of water-sprays introduced in the flue at a point before the gases enter the treater. It has been found that a considerable additional saving in values is possible by passing fumes through two sections of the treater in tandem.

The precipitated fume in most cases can be ignited in the treater in the same manner as bag-house fume and this sintered material is then in good condition for smelting in the blast-furnace.

An interesting installation of the vacuum system of handling flue-dust and bag-house fume has been developed at the Selby smelter in San Francisco. With this equipment it is possible to clean the bag-house compartments much more quickly and thoroughly and at the same time prevent a dusty and unhealthy atmosphere incidental to the work when cleaning by the old method with shovel and wheelbarrow. This apparatus consists of flexible suction-pipe, which can reach various parts of the bag-house basement. Fume is collected in a specially designed cyclone collector, the collector being connected to the suction side of a high-

vacuum exhauster. The fume from the collector is mixed in a pug mill into a thick mud and smelted direct in the blast-furnace.

Softening.—At the Bunker Hill smelter there has been installed a circular merchant furnace. This furnace replaces four 50-ton merchant kettles. The furnace is fired by pulverized coal and is much more economical, requiring less fuel, and produces less dross than the kettle. The temperature of the lead can be kept more constant.

Leading Articles of the Year

Pertaining to the Metallurgy of Lead

Influence of Impurities in Lead on its Resistivity to Acid.—This subject is discussed in a paper by C. E. Bavis before the December, 1919, meeting of the London Section of the Society of Chemical Industry. Reference to this paper is made in *Chemical and Metallurgical Engineering* for Feb. 11, 1920.

Chemical Lead.—The qualities and composition of chemical lead are discussed,[1] with abstracts from D. W. Jones' article on "Chemical Sheet Lead," which was published in the journal of the Society of Chemical Industry for July 31, 1920. In this article, the requirements of chemical lead for acid-chamber purposes are outlined and the experiments regarding lead for this purpose, as carried on by Mr. Jones, are also discussed.

The Problem of Reducing Lead Sulphate.—F. N. Flynn describes[2] the formation of certain lead-sulphate compounds in metallurgy and the smelting and wet methods of reducing them for the recovery of lead in a metallic form.

Ore Buying in Mexico.—An article by C. A. Grabill[3] contains many interesting points regarding the methods used by the smelters of Mexico in purchasing lead-silver ores, as well as ores containing other metals. The article also contains a list of the principal smelting plants in Mexico and their locations.

Progress in Powdered Coal for Blast-furnaces.—Reference is made in an article[4] by W. L. Wotherspoon to the use of pulverized coal on lead blast-furnaces, at the Midvale smelter of the U. S. Smelting, Refining & Mining Co., near Salt Lake City. At this plant, approximately 30 per cent. of the normal coke requirement has been replaced by coal. This article also describes the application of powdered coal at various copper smelters and illustrates the apparatus whereby the coal is introduced at the furnace and describes and illustrates a new safety vortex tuyere, particularly adapted for delivering powdered coal to the furnace.[5]

[1] *Eng. Min. Jour.*, Dec. 4, 1920.
[2] *Eng. Min. Jour.*, Feb. 21, 1920.
[3] *Eng. Min. Jour.*, Mar. 20, 1920.
[4] *Eng. Min. Jour.*, Apr. 3, 1920.
[5] For details see page 182.

Primitive Smelting.—A most interesting article by C. A. Grabill[1] described and illustrated the native practice of lead and silver recovery in Mexico.

The Lead Industry of France.—Richard H. Vail gives[2] the status of various metallurgical plants in France. The lead industry is undergoing expansion.

Lead and Zinc Industry in Japan.—In the report[3] of Vice Consul H. T. Goodier of Yokohama this subject is discussed in considerable detail.

Lead and Zinc Situation in Japan.—A summary of the lead and zinc situation in Japan is given in an editorial in the *Mining and Scientific Press* for Aug. 21, 1920.

The Burma Corporation, Ltd.—A review of the operations of the Burma Corporation, Ltd., is contained in an editorial[4] from which we quote:

"The ore reserves of the Burma Corporation, Ltd., are reported as 4,732,003 tons of approximately the following value: 26.4 per cent. lead, 1.2 per cent. copper, 18.2 per cent. zinc, and 24.5 oz. of silver per ton.

"In December, 1919, a new company was incorporated at Rangoon with a capitalization of 20,000,000 shares, of 10 rupees each, together with £1,000,000 of 8-per cent. convertible stock, the purpose of the latter being to provide funds for the completion within three years of the metallurgical plants, power projects and railway construction necessary to treat 1650 tons of high-grade ore daily. The present earnings of the company are at the rate of £600,000 per year, and since £1,600,000 will suffice to carry out the proposed construction and equipment, it is apparent that before long the current profit should be available for dividends.

"The company has recently acquired a new lease for 30 years from the Indian Government on the 10 square miles of ground that includes the mine at Bawdwin.

"About 1,600,000 tons of lower-grade ore is proved, but nothing is included in the calculations that does not contain at least 20 per cent. of combined lead and zinc. At present the mine is in condition to produce 1500 tons of lead-zinc ore and 150 tons of copper ore per day.

"The existing plants include a smelter, which has been treating high-grade ore, at Namtu, 13 miles from Bawdwin, since 1911, and a new concentrator, with a present capacity of 800 tons per day, which since being started recently has supplied lead concentrate instead of raw ore to the smelter.

"A 2500-kw. generating station is to be built at Nam Ma, where the company's geologists have discovered a deposit of semi-bituminous coal

[1] *Eng. Min. Jour.*, Apr. 17, 1920.
[2] *Eng. Min. Jour.*, Apr. 24, 1920.
[3] *Comm. Rept.*, May 24, 1920; *Chem. Met. Eng.*, June 30, 1920.
[4] *Min. Sci. Press*, Sept. 4, 1920.

of good grade. Approximately 7,000,000 tons has already been proved; this will replace the almost exhausted supply of wood for fuel at the smelter, as well as operate the steam electric plant. The development of this coal was one of the factors that determined the selection of Namtu as the site for the new smelter."

Smelting at Namtu, Burma.—Arthur W. Jenks, formerly Smelter Manager, describes[1] the difficulties experienced during the war at the Burma plant and also gives a great deal of data relative to general conditions at that plant.

Methods of Ore Sampling in Montana.—H. B. Pulsifer describes[2] methods and equipment at various ore samplers in considerable detail. The article is well illustrated with interior and exterior views of the various plants.

White Lead.—A committee in New York has been taking testimony regarding the prices of white lead, and according to evidence placed before the committee, it was shown that four companies controlled the manufacture of 95 per cent. of the white lead made in the United States. It was also shown that the price of white lead had advanced from 6 cts. per lb. in 1916 to 15½ cts. in December, 1920. The sales of the National Lead Co. amounted to over $21,000,000 in 11 months of 1920.

Metallurgical Plants in the Vicinity of New York.—Edward H. Robie has an article in the *Engineering and Mining Journal* of June 22, 1920, outlining the metallurgical industry in the vicinity of New York, illustrated by a map showing the location of the various smelters and refineries in that district.

Lead Mining and Refining Companies.—The *Engineering and Mining Journal* of Sept. 18, 1920, gives a list of companies in the United States engaged in lead mining, smelting and refining. The list is as follows:

American Smelting & Refining Co., 120 Broadway, New York. (Subsidiary companies all over the United States.)

American Metal Co., 61 Broadway, New York. (Has several subsidiary companies.)

Bunker Hill & Sullivan Mining & Concentrating Co., 1022 Crocker Bldg., San Francisco. (Smelting company is a subsidiary.)

St. Joseph Lead Co., 61 Broadway, New York.

Anaconda Copper Mining Co., 42 Broadway, New York. (Controls subsidiary lead companies.)

U. S. Smelting, Refining & Mining Co., 120 Broadway, New York. (Controls subsidiary lead companies.)

Eagle-Picher Lead Co., Joplin, Mo.

American Zinc, Lead & Smelting Co., 55 Congress St., Boston, Mass. (Controls a subsidiary lead company.)

Northport Smelting & Refining Co., Northport, Wash. (Controlled by Hercules

[1] *Eng. Min. Jour.*, Aug. 14, 1920.
[2] *Min. Sci. Press*, Dec. 18 and Dec. 25, 1920.

Mining Co., in Burke, Idaho, and Tamarack & Custer Mining Co., Wallace, Idaho. The bullion is refined by the Pennsylvania Smelting & Refining Co., at Pittsburgh.)

National Lead Co., 111 Broadway, New York. (Controls a subsidiary.)

Lead Smelting.—A paper by Gilbert Rigg, entitled "Roasting and Lead Smelting Practice at the Port Pirie plant of the Broken Hill Associated Smelters Proprietary, Ltd.," appeared in the May bulletin of the Institution of Mining & Metallurgy.

This paper gives in detail experiences in roasting the products by two methods. The two classes of concentrates treated consist of coarse concentrates and slimes, analyzing as follows:

	Coarse Concentrates.	Slimes.
Pb	63.0	57.0
Zn	7.0	11.0
Fe, Mn	4.7	4.3
S	14.5	18.0
CaO	1.5	1.5
Al_2O_3	1.5	1.0
SiO_2	5.0	3.5

In the first method, the two grades were mixed with oxidized lead ore, limestone and ironstone, after which the charge was given a preliminary roast in Ropp reverberatory roasters and the product was then transferred to Huntington-Heberlein pots for a final roast. In the second method, the mixture of concentrates was given a preliminary roast on Dwight-Lloyd machines, then crushed and again passed over Dwight-Lloyd machines.

The first method gave the best results, but neither method was considered entirely satisfactory. Further investigation proved that the sulphur combined with zinc is more easily roasted off than that combined with lead. The trouble caused by zinc is that rapid evolution of heat results and tends to fuse the galena. The presence of ½ to ¾ -in. pieces of limestone and ironstone in the charge was found to be undesirable, and this material should be crushed as fine as the rest of the charge for the Dwight-Lloyd roasting.

Handling the dried slime concentrates by means of screw-conveyors was found to disintegrate the lumps to a great extent. Belt-conveyors were afterwards installed and resulted in a much more satisfactory roast. Water-granulated blast-furnace slag was found to be preferable to ironstone. It also contained silica and lime, which was an advantage in the mixture. After making the above changes, the second roast yielded sinter of the following percentages:

Pb	47.5 to 48.5
Zn	7.5
SiO_2	8.0 to 8.5
FeO	13.0 to 14.0
MnO	3.0
CaO	5.5 to 6.0
S	2.5 to 3.0

The Dwight-Lloyd machines will, therefore, be used for initial roasting, but whether H. &. H. pots will be employed for final roasting has not been decided. The H. & H. sinter was found to be stronger than the Dwight-Lloyd, but less porous. The H. & H. is more massive and stands more rough handling, but the blast-furnaces run better on a mixture of the two products.

The writer also discussed the roasting of Broken Hill zinc concentrates in the same paper. He remarked that zinc is a trouble-maker in blast-furnaces only when combined with sulphur. Then, a zincky matte of a mushy consistency containing about 14 per cent. zinc lends itself to the building up of accretions inside the furnace. With more copper in the ore, higher sulphur can be carried.

The blast-furnace, with the improved roasting, runs smoothly and hot. The composition of the slag is about as follows:

SiO_2	24.2
FeO	25.6
MnO	5.3
CaO	11.0
ZnO	20.0
Pb	1.0 to 2.0

Later it is hoped to recover some of the zinc, either by blast treatment or in a reverberatory furnace.

The June issue of the bulletin of the Institution of Mining and Metallurgy contains twenty pages of discussions of Mr. Rigg's paper on Broken Hill practice.

Smelter Smoke in Salt Lake Valley.—The *Engineering and Mining Journal* of June 19, 1920, reviews the decision regarding smoke litigation, from which we quote as follows:

"Federal Judge T. D. Johnson has recently handed down an interesting opinion in the smoke suits brought by farmers in the Salt Lake Valley against the American Smelting & Refining Co. and the United States Smelting Co. The judge's statement brings out the conflicting character of much of the testimony and shows that little has actually been proved. The testimony of the farmers' experts, Professors Pierce and Mitchell, was weakened because they assumed that leaf markings which had the appearance of SO_2 burning were in all cases caused by this gas. Judge Johnson says their generalization was unwarranted and tended to make all of their testimony of uncertain value.

"On the other hand, the testimony presented by the defendants, much of it incapable of proof, was also probably somewhat colored by personal feelings in the matter. The judge brought out, however, that the smelting companies, particularly the A. S. & R., have gone to con-

siderable expense in investigating, by scientific methods, the effect of smelter smoke, and that their testimony in general had much more value for this reason.

"In the opinion of the court, much of the damage laid at the door of the smelters was actually caused by frost, alkali in the soil, sun-scald following irrigation, or sun-burn resulting from lack of moisture. Nevertheless, there were cases where the damage was admittedly caused by SO_2, and Judge Johnson, in concluding, advised the smelting companies to carry their investigations further and to devise some method by which the troublesome gas could be eliminated so that no cause for future complaints would exist. Failing in this, he indicated that the smelters would be denied the right to operate."

E. E. Thum wrote an illustrated article[1] on the smoke litigation in the Salt Lake Valley. The history of the suits is given briefly and the principal points in the decree issued by Judge Johnson are discussed. The A. S. & R. has reduced injury by closing down certain smelting units when conditions of light, temperature, humidity and wind direction are unfavorable.

The report of the United States Bureau of Mines, which coöperated with Osborne Monett, a fuel engineer of Chicago, announced that the smoke from the Salt Lake Valley smelters was diffused before reaching Salt Lake City and was therefore not a factor in the smoke problem of that city.

Tooele Flue-type Cottrell Treater.—A description of a new type of treater that was started at the Tooele plant of the International Smelting Co. is given in an article by A. B. Young.[2] The installation consists of a simple flue, containing corrugated plates placed vertically. These plates form the grounded electrode. Between the plates are small pipes placed horizontally and spaced 6 in. center to center. These form the negative electrode. Beneath the electrodes are steel hoppers with screw-conveyors to catch and collect the deposited dust and fume that falls and is jarred from the electrodes, by means of hand-operated knockers.

The operation of the treater has shown a decided selective principle, so that the material collected in certain parts of the treater is smelted in the copper department and other material may be segregated and smelted for lead.

The capacity or volume of gas handled has exceeded expectations. The power input is given at approximately 8.4 KVA for the first section and 5.5 for the second, this when handling from 125,000 to 150,000 cu. ft. of gas per minute.

[1] *Chem. Met. Eng.*, June 23, 1920.
[2] *Min. & Met.*, June, 1920; *Trans. Am. Inst. Min. Met. Eng.*, **64.**

Approximately 85 per cent. of the dust collected is caught by the first compartment and 15 per cent. by the second compartment.

Patents Pertaining to the Lead Industry

Chloridizing Process.—An article on a chloridizing process by Harai R. Layng[1] reviews the field of chloridizing and cites the work of others along this line. The author believes that quick heating is necessary, which is contrary to the belief of Croasdale, Stevens, Wighton and others. The author believes in a bag-house for collecting fume, and cotton bags are preferred for the chloride fume. The cost of a plant is given roughly at $750 per ton of capacity. This article is the basis of a patent application by Mr. Layng.

Recovering Lead and Tin.—Lead and tin are recovered from materials containing them in a process patented by W. G. Rumbold of London.[2] By this process, lead is recovered by a treatment of hot ferric-chloride solution and tin is recovered with hot ferric-chloride or ferric-sulphate solution. To the resulting solutions, substantially free from acid, there is added about one-third of their volume of concentrated ferrous-chloride or ferrous-sulphate solution and the lead or tin is then precipitated by means of scrap iron. The deposition is preferably carried out by adding from time to time successive portions of solution to be treated to solutions from which the material has already been deposited.[3]

Lead Plating.—Robert J. Shoemaker of Milwaukee, Wis., secured United States Patent No. 1,330,399, Feb. 10, 1920, upon a method of lead plating by the aid of a certain flux. Lead plating with iron and steel sheets or other articles may be accomplished in a manner similar to galvanizing. The flux consists of 80 per cent. zinc chloride, 15 per cent. sodium chloride and 5 per cent. tin chloride. By means of a frame, a considerable amount of flux is maintained on the surface of the molten metal at the point at which the work enters. A thin layer of flux covers the rest of the bath. An alloy of 85 per cent. lead, 10 antimony and 5 per cent. tin is recommended for the production of an adherent uniform coating, free from pinholes.

Refining Lead.—H. Harris, of London, has invented a process for dezincking lead.[4] The process consists in heating the molten lead with a molten mixture of an alkali chloride and a substance which lowers the melting point of the alkali chloride, e.g., caustic alkali or zinc chloride in the presence of a source of oxygen such as air or litharge. The treatment of lead with a mixture of zinc chloride and litharge is also referred to.

[1] *Min. Sci. Press*, Jan. 17, 1920.
[2] British Patent No. 135,052 (1919).
[3] Complete specifications of any British patent may be obtained by remitting 25 cts. each to the Superintendent, British Patent Office, South Hampton Buildings, Chancery Lane, London, England.
[4] British Patent No. 142,315 (1919).

Treating Lead and Silver Ores.—A method of treating lead and silver complex sulphide ores has been patented by the Amalgamated Zinc, Ltd., of Melbourne, Australia.[1] By this method ores are treated by mixing with hydrochloric acid in quantities sufficient for the desired reaction, and heating to a temperature above 100° C. The ore is mixed with the acid, dried at a temperature below 100° C., and heated at a higher temperature, which may be 500 to 600°, preferably in a closed vessel. The operation is facilitated if some copper is present in the ore. The mixture of ore and acid may be allowed to stand some time before the drying and the furnace product may be moistened and left for some time before leaching. The product may be leached with hot brine containing some ferric chloride to dissolve both lead and silver chloride with a minimum time of contact between liquor and ore.

Lead Arsenate.—A method of manufacturing lead arsenate was patented by Mr. Mathew W. Butler and assigned to the Harshaw, Fuller & Goodwin Co.[2]

Roasting Lead-zinc Sulphide.—Late in 1919, Mr. M. F. Collbaugh patented a process of roasting lead-zinc sulphides.[3]

Reinforced Lead.[4]—Ordinary lead sheet when suspended in large sheets or pipes creeps and sags so that frequent supports are necessary to hold it in place, as in sulphuric-acid chambers, tank-cars, etc.; also on lead-coated iron braces or when lead is attached to retaining walls and pulp-digesters, petroleum-refining tanks, etc., and in vacuum pans, the connections of lead must be of extra heaviness of ¾ to 1-in. thickness and great weight in order to prevent collapsing. Many of these troubles in the use of lead have been overcome and diminished by reinforcing lead with iron or steel wire gauze or perforated sheets which are imbedded within the lead. This method of reinforcing has been patented under United States Patents Nos. 1,280,908 and 1,280,909. By this method the elastic limit has been increased four or five fold and the tensile strength has also been increased two or three fold. The variations were due to difference in gauge of wire and mesh of gauze used. Both may be materially increased by increasing (within limits) the gauge and looseness of weaving of the gauze. When manufactured, the surface of the lead, or lead alloy, may be somewhat rough and unnecessarily thick. Both are easily remedied by rolling as in making sheet-lead. Lateral extensions of 20 per cent. and elongation of 30 per cent. have been obtained, the main care being against tearing the reinforcing wire gauze. Sheets 4 ft. 6 in. by 5 ft. 6 in. have been made. For obvious reasons

[1] British Patent No. 142,854 (1919).
[2] U. S. Patent No. 1,323,300, Dec. 3, 1919.
[3] U. S. Patent No. 1,315,761.
[4] Chas. Baskerville and C. M. Wales, *Chem. Met. Eng.*, June 9, 1920.

smoothing the surface is advisable only when the reinforcing member is perforated sheet-iron or steel.

The reinforcing sheets may be bent to shape almost at will, as the lead does not fracture when bent. The sheets may be cut and joints are easily burned together in the same manner as ordinary sheet-lead. The lead may also be melted from the edge of the sheet and the piece shaped into pipe, the overlapping edge being then burned into position.

A pipe 8 in. in diameter, made up of reinforced lead 0.2 in. in thickness, collapsed at 85 lb. per sq. in. pressure. The experimental work on this material was carried out by V. A. Belchert, College of the City of New York.

Burma Corporation, Ltd., New Smelter

The Burma Corporation, Ltd., is at the present time, engaged in the construction of a new, modern metallurgical plant near their mines at Namtu, Upper Shan States, Burma. This plant, when completed, will replace the old smelting plant and refinery, which is out of date and no longer economical.

The ores and concentrates to be handled are lead-zinc sulphides containing a high percentage of iron. These products will be handled from the mine and mill to the smelter by specially designed 20-ton side-dump steel ore-cars, these cars dumping by gravity into the ore receiving bins. The ores and fluxes are reclaimed from beneath the receiving beds by means of three belt-conveyors, fed by adjustable gates from hoppers.

The material is conveyed to an equalizing bin fed with a 3-ft. drum feeder. This feeder is attended by a coolie and delivers the material into a No. 7½ gyratory crusher. From the No. 7½ gyratory the product is divided and delivered to two No. 4 gyratory crushers, the product from which goes to 4 Mitchell screens, with ½-in. openings. The undersize from the screens passes to two 54-in. rolls set at ⅛ in. The oversize from the screens is delivered to two 54-in. rolls in closed circuit with the Mitchell screens.

The crushing plant will be capable of delivering 125 tons per hour of final product. The coarse-crushing department has a capacity of 250 tons per hour with provision for enlarging the fine-crushing section, so that the total capacity of the plant may ultimately be 250 tons of ⅛-in. product per hour. The product of the crushing plant is then sampled by automatic samplers and conveyed by belts to the fine-ore bins. These fine-ore bins are each provided with two endless-belt feeders, whereby the material can be accurately measured and delivered to the main conveyor-belt, transporting the crushed ore and fluxes to the roasters. This system of feeding—conveying system—gives the proper proportion

of each constituent of the charge a thorough mix before it enters the roasting department.

As the sulphur elimination requires pre-roasting, various schemes have been tried to accomplish this in the most economical manner. Pre-roasting on Dwight-Lloyd machines was not found satisfactory on account of the rapid fusing of the charge, resulting in a solid slagged product that requires recrushing at an additional expense, also enveloped particles of raw ore, in this way hindering sulphur elimination. It has, therefore, been decided to use Godfrey roasters for the preliminary roasting. The product from the Godfreys is conveyed to storage-bins by railway cars and from storage-bins to the Dwight-Lloyd department by conveyor-belt. The roasting will be completed on Dwight-Lloyd machines, there being twelve machines in the original installation, with provision for extensions of this plant.

The product from the Dwight-Lloyd machines falls directly into steel cars and is transferred by rail to the blast-furnace charge-bins.

The plant and equipment outlined above constitute the first units to be constructed, and pending construction of the new blast-furnace plant and refinery, the roasted material from the new roasting department will be delivered to the old blast-furnace plant for smelting and refining. The new blast-furnace plant and refinery, as now contemplated, is as follows:

The blast-furnace charge will be mechanically weighed into a specially designed charge-car and transported to the blast-furnace by electric locomotives. There will be four lead blast-furnaces installed in the first installation. These furnaces will be placed end to end to facilitate charging and operation. The products and by-products will be handled from the blast-furnaces in a similar way to that at the Bunker Hill smelter at Kellogg, Idaho—the slag by means of large-capacity electrically operated cars, the matte and lead bullion by electric crane.

Refining will be by the Parkes process; the arrangement and various stages of the process will be such as to insure the most economical handling of the products and by-products.

The recovery of values from the fumes and gases has been well thought out and separate bag-house installations will be provided for the various departments. The gases from the bag-houses will be carried away by high stacks.

Provision has been made in every department for enlargement and extensions wherever this may be required. The design of the plant is under the direct supervision of R. G. Hall, Resident Manager, assisted by W. R. Degenhardt, the Chief Engineer of the company. Bradley, Bruff & Labarthe act as consulting engineers.[1]

[1] NOTE.—Since this article was written the work on the new smelter for the Burma Corporation has been discontinued and its construction indefinitely postponed.

MAGNESITE

By Samuel H. Dolbear

Early in 1920 producers of magnesite in the United States anticipated a complete suspension of operations due to foreign competition. Upon this basis, an intensive effort was made to secure tariff protection. At the close of 1920, the Fordney tariff bill had not been passed, in spite of which fact, domestic production had increased in 1920 about 94 per cent. over that of 1919. This is the second-largest yearly production ever recorded by the United States, lacking but a few thousand tons of the intensive war-time production of 1917.

Of the total of 303,767 short tons of crude ore mined, sold or treated in 1920, the mines of the Chewelah district in Washington yielded 221,985 tons, and those of California 81,782 tons. Production in the United States came entirely from these two States; deposits reported to have been found in Nevada, New Mexico and other states were not active.

STATISTICS OF CRUDE MAGNESITE IN THE UNITED STATES
(Tons of 2000 lb.)

Year.	Production. (a)	
	Tons.	Value.
1907	7,561	$22,683
1908	6,587	19,761
1909	9,465	37,860
1910	12,443	74,658
1911	9,375	75,000
1912	10,512	84,096
1913	9,632	77,056
1914	11,293	124,223
1915	30,499	274,491
1916	154,974	1,393,693
1917	316,838	2,899,818
1918	231,605	1,812,601
1919	156,226	1,248,415
1920	303,767	2,748,150

(a) U. S. Geol. Surv.

Imports

Imports in 1920 increased from 14,153 long tons in the previous year to 43,154 tons of crude and calcined but not purified material. While this represents an increase of nearly 300 per cent., the amount was only about one-seventh of the tonnage imported before the war.[1] The imports came chiefly from Italy, which shipped 21,185 tons. This material was actually produced in Austria, but was cleared from Italian ports. Im-

[1] U. S. Geol. Surv.

ports from Canada ranked second, amounting to 6028 tons, the remainder coming from 11 other countries.

IMPORTS OF MAGNESITE INTO THE UNITED STATES

	1919.		1918.		1920.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Magnesia:						
Calcined (Medicinal)	423	$312	22,637	$11,358	26,859	$9,903
Carbonate (Medicinal)	*Nil*	.....	5,094	1,101	14,930	1,512
Sulphate	2,046	196	17,647	1,473	1,803,769	66,944
Magnesite:						
Calcined, not purified	38,098,815	824,022	18,941,440	270,721	29,560,000	373,165
Crude	10,863,417	103,233	12,761,280	103,311	67,100,000	406,204

IMPORTS OF MAGNESITE CALCINED, NOT PURIFIED
(Fiscal years ending June 30, in long tons)

Country.	1916.	1917.	1918. (a)	1919. (a)	1920. (a)
Europe:					
Austria-Hungary	.....	.....	.....	2,366	(b)3,829
Germany	12	.....	.....	30	713
Greece	11,413	1,792	.....	.....	4,437
Italy	.....	.....	.....	2,157	21,185
Netherlands	1,950	.....	.....	.....	819
United Kingdom—					
England	.....	27	2	26	28
Scotland	349	757	774	84	190
North America:					
Canada	2,440	2,148	17,860	7,202	6,028
Mexico	.....	.....	.....	2,288	500
Other countries	.....	.....	.....	.....	5,425
Total	16,186	4,724	18,636	14,153	43,154

(a) Calendar years.
(b) Czecho-Slovakia.

Foreign Countries

Greece.—This country exported 4437 tons to the United States in 1920. This ore, which is chiefly used in the production of plastics, was the first to be shipped to the United States from the Grecian mines since 1916. Ore of the character produced in Greece competes with the mines of California rather than those of Washington, the material from the latter State being converted entirely into ferro-magnesite for refractory purposes.

Czecho-Slovakia (Austria-Hungary).—Shipments of 3829 tons reported from Czecho-Slovakia came from former Hungarian mines. It is reported that the control of these deposits has passed into French hands, and that an effort is being made to consolidate the Veitcher Magnesitewerke with the Steirische company. The latter concern is controlled by the Allgemeine Depositenbank.

Mexico.—But 500 tons was produced in Mexico in 1920. This came entirely from deposits on Santa Margarita Island, in the gulf of Lower California. It was shipped to a calcining plant near San Diego, Calif.

Canada.—Production was greater in 1920 than in 1919, but less than in the previous three years. The total mined during the year was 31,040 short tons, of which 30,230 tons was calcined, yielding 3152 tons of caustic or light-burned magnesite and 11,894 tons of clinkered or dead-burned material. Out of these amounts, 7753 tons was sold for export, 6028 tons going to the United States. The Canadian mines are chiefly located in Argenteuil County, Quebec. Two new plants for burning ore were built at Calumet during the year.

Venezuela.—With shipments to the United States amounting to 2300 tons, Venezuela became a producer of moment. By an odd coincidence the magnesite deposits of this country are situated on an island named Santa Margarita, as are also those of Mexico. Some confusion has occurred because of this fact.

United States

At the close of 1919 many mines in the United States had either closed down or were operating at low capacity. Operations were resumed early in 1920 and continued at capacity until December. By the latter part of that month all of the Washington mines had ceased production, due to a lack of orders from the steel mills. The latter were reported to be working at only 20 per cent. of capacity, and this, taken with imports, resulted in the failure of the market for domestic supplies.

Washington.—The Northwest Magnesite Co. at Chewelah, Stevens County, is the largest producer of magnesite in the United States, its product going entirely to steel and refractory manufacturers. Its production in 1920 was in excess of 90,000 tons of ferro-magnesite.

The American Mineral Production Co. produced chiefly crude ore which was sold to the Northwest Magnesite Co., whose quarries are nearby. The mines of the two companies are connected by half a mile of narrow-gage railway.

The Western Materials Co. operated the Double Eagle deposits, this concern being controlled by the American Refractories Co. of Pittsburgh. The latter company also controls the Austro-American Magnesite Co. at Rhadentheim, Austria.

California.—The region in the vicinity of Porterville, Tulare County, continues to yield the largest tonnages mined in California. This is due chiefly to the activity of the Tulare Mining Co., whose mines and kilns are situated about 14 miles northwest of Porterville. This concern, in addition to its original operation, has purchased the adjoining Adams mine on the north, and the Hawley mine on the south, which gives it a magnesite-bearing area several thousand feet in length.

The Sierra Magnesite Co. has taken over the custom plant in the town of Porterville from the American Magnesite Co. and has been receiving ore from several of the smaller mines in the locality.

The Porterville Magnesite Co., at one time the largest producer in the district, was reported to have passed into the hands of a receiver, and to have been later sold to the Kellastone Co. of Chicago.

These operators, with the White Rock mine in Napa County and the Western Materials Development Co. in Santa Clara County, produced most of the magnesite sold in California during the year. The California ore was sold chiefly for plastic purposes, only a small amount being clinkered for steel mills on the Pacific Coast.

THE PRINCIPAL SUPPLIES OF MAGNESITE
(In metric tons)

Year.	Austria-Hungary. (a)		Greece.		India. (b)	Italy. (b)	United States. (b)	Canada. (b)
	Crude.	Calcined.	Crude.	Calcined.				
1905	.....	92,359	37,063	.....	2,645	.....	3,568	.....
1906	.....	87,765	40,584	.....	1,861	.....	7,093	.....
1907	452	113,695	55,816	.....	188	.....	6,858	.....
1908	212	87,049	63,079	.....	7,655	.....	5,994	109
1909	341	182,911	18,073	.....	5,264	.....	11,251	299
1910	1,027	125,666	56,797	19,182	199	.....	8,588	293
1911	77	182,911	86,956	16,609	3,546	.....	8,505	800
1912	.....	171,196	106,338	27,530	15,626	.....	9,534	1,555
1913	.....	200,947	98,517	33,848	16,468	600	8,741	467
1914	.....	.....	136,701	31,815	1,706	1,410	10,248	325
1915	.....	.....	159,981	28,563	7,570	9,200	27,669	13,407
1916	.....	.....	145,533	28,563	17,924	18,252	140,592	50,261
1917	.....	.....	162,938	27,248	18,495	31,071	287,433	52,699
1918	.....	.....	39,340	69,837	5,947	28,882	225,161	35,712
1919	.....	(c) 8,000	29,885	.....	17,402	35,930	137,972	10,317
1920	.....	.....	63,516	.....	.....	.....	275,577	16,673

(a) Exports. (b) Crude magnesite. (c) Estimated.

MAGNESIUM

Magnesium is the lightest metal now known that remains comparatively unaltered under ordinary atmospheric conditions. It is only two-thirds as heavy as aluminium. It has been made in the United States only since 1915 and is now made in but three plants. Previously it was imported from Germany for many years, principally in the form of the powder for use in making flashlights. During the war large quantities of the powder were made in the United States for use in star shells designed to illuminate battlefields at night, and also in special shells designed to show in the daytime exactly where the shells containing it exploded, by means of the white smoke-cloud. Magnesium in massive form, as sticks or rods, is used to deoxidize other metals in foundries and is a constituent of alloys. More magnesium is now used as a deoxidizer or scavenger in metallurgy than for any other purpose, but its

employment in alloys is increasing and may eventually become the largest one. An alloy of magnesium and aluminium is used in making castings for aircraft engines and parts of airplanes. The skeleton of the British airship R-34, the first dirigible to cross the Atlantic, is an alloy of aluminium and magnesium, and the yacht *Resolute*, the defender of the *America's* cup in the races in July, 1920, as well as the alternative defender the *Vanitie*, carried gaffs made of this alloy. Since the war the demand has slackened, as shown in the following table:[1]

METALLIC MAGNESIUM PRODUCED IN THE UNITED STATES, 1915–1920

Year.	Number of Producers.	Quantity, Pounds.	Value.	Average Price per Pound.
1915	3	87,500	$440,000	$5.00
1916	4	75,400	311,462	4.13
1917	5	115,813	233,626	2.02
1918	4	284,188	615,217	(a) 2.16
1919	3	127,465	247,302	1.94
1920	2	(b)	(b)	(c) 2.75

(a) As 1918 was the first year in which powdered magnesium was reported to the Geological Survey, the average price of $2.16 a pound for all magnesium sold in 1918, which includes a large quantity of powdered magnesium, is not comparable with the average price for 1917, which is based on magnesium in sticks only. The average price for stick magnesium in 1918 was about $1.81 a pound, or 21 cents less than in 1919. (b) Permission for publication not given. (c) Powder.

Imports.—During 1920, 29,275 lb. of magnesium, valued at $25,055, was imported, compared with 13,239 lb. valued at $13,583, in 1919. During the last six months of 1918 the imports were 11,899 lb. valued at 16,259. Prior to 1915 the entire domestic supply was imported, but such imports are not separately shown until July, 1918.

Electron Alloys.[2]—The term "electron" is a general term for a series of magnesium alloys containing over 80 per cent. by weight of magnesium, with slight additions of other metals such as zinc. These are manufactured by the Chemische Fabrik Griesheim Elektron in Germany, according to an article in *Zeitschrift des Vereins deutscher Ingenieure.* An abstract published by *Technical Review*, London, follows:

Electron is a silver-white metal similar in appearance to aluminium, and suitable for casting or pressing. Considerable difficulties have now been overcome in the casting of this alloy and all types of castings formerly produced in aluminium (sand cast) can now be made of electron. The slabs, which when delivered generally weigh 2 kg., are smelted in wrought-iron or cast-steel crucibles of 6 to 12 liters capacity. The metal should be poured before it is actually quite fluid. Slight overheating is only necessary in the case of thin-walled or very large castings. The melting point, which is 630° C., should not be exceeded by more than 50° C., as otherwise the thin oxide film floating on the surface commences

[1] U. S. Geol. Surv.
[2] *Iron Age*, June 16, 1921.

to burn. To extinguish a fire caused through too high a temperature about 20 to 30 kg. of a calcium alloy should be added. The calcium has a protective effect and prevents oxidation for some time, although it has the effect of making the casting brittle and sensitive to atmospheric influences. Owing to the low temperature at which the alloy may be overheated, it is advisable to pour large or thin-walled castings into molds which are as hot as possible or which are taken directly from the drying oven.

The mean tensile strength of electron metal castings is 12 to 15 kg. per sq. mm. and the elongation 3 to 4 per cent. Thick-walled, carefully-cooled castings have a tensile strength of 2 to 3 kg. per sq. mm. less, and about 3 per cent. elongation. The reduction in area is approximately the same as the elongation, and the yield point at 8 to 10 kg. per sq. mm. The Shore scleroscope value is from 10 to 15.

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MANGANESE

By Marshall Haney

Principal Features for the Year 1920.[1]—The domestic manganese industry during the year 1920 suffered, like practically all other mining industries, from adverse conditions, but nevertheless the production was considerably greater than it was in 1919. Early in 1920 the stocks of manganese ore and ferro-alloys were evidently very largely depleted, and the market for domestic ores was thus considerably improved. While the production of steel during 1920 was about the same as in the preceding four or five years, the depletion in stocks of manganese ore and ferro-alloys caused a bigger demand than was experienced in 1919. The production increased in all grades during the year, but the greatest percentage of increase was in the production of high-grade ores. The total output of high-grade ores was 94,000 long tons. About 76,441 tons came from the State of Montana alone, and of this amount the Anaconda Copper Mining Co. produced about 56,000 tons, or slightly more than the total domestic production of high-grade ore in 1919.

The final figures for the remaining states are not available at this time, but sufficient data are at hand to indicate that in those states, taken together, there was little or no increase in production.

UNITED STATES PRODUCTION AND IMPORTS
(Long tons)

Year.	Ore.			Ferromanganese.			Spiegeleisen.	
	Imports. (*b*)	Production. (*b*)	Production. (*c*)	Imports.	Av. Value per Ton. (*a*)	Production.	Imports.	Production.
1911...	176,852	2,457	522,357	80,263	$37.56	74,482	20,970	110,236
1912...	300,661	1,664	868,501	99,137	39.41	125,378	1,015	96,346
1913...	345,090	4,048	672,146	128,070	44.37	119,496	77	110,338
1914...	283,294	2,635	445,827	82,997	41.33	106,083	2,870	79,935
1915...	313,985	9,709	801,290	55,263	60.31	146,542	200	93,282
1916...	576,321	26,966	548,803	90,928	101.62	221,532	*Nil.*	194,002
1917...	629,972	114,216	1,103,503	45,381	134.58	257,842	3,968	188,852
1918...	491,303	305,869	1,145,531	27,168	156.75	345,306	1,969	249,002
1919...	333,344	55,322	433,733	33,022	129.72	179,079	27	65,391
1920...	606,937	94,000	673,000	54,254	131.22	282,681	5,234	103,448

(*a*) At foreign port, no freight or duty. (*b*) High-grade manganese ore. (*c*) Manganiferous ore, not including manganiferous zinc ore.

There was also a notable increase in the production of ore containing 10 to 35 per cent. of manganese, most of which, as usual, came from Minnesota, Nevada and Colorado. The Nevada ore, as in previous

[1] H. A. C. Jenison, U. S. Geol. Surv.

years, was utilized principally as flux. Most of the Colorado ore (34,661 tons) was also used for fluxing. The production of low-grade ore, containing 5 to 10 per cent. of manganese, also showed a large increase, practically all of it in Minnesota. To the high iron content of this ore is largely due its ability to find a market in 1920.

The imports showed a great increase in 1920, Russia for the first time since 1914 making an important contribution. The imports from India also were almost eight times as great as they were in 1919. Imports from Brazil, though not increasing as much as those from India, were very greatly in excess of those in 1919.

MANGANESE AND MANGANIFEROUS ORE SHIPPED FROM MINES IN THE UNITED STATES
(In long tons)

Year.	Ore Containing 35 Per Cent. of Manganese or More.		Ore Containing 10 to 35 Per Cent. of Manganese.		Ore Containing 5 to 10 Per Cent. of Manganese.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1913	4,048	$40,480	51,512	(a)$25,124	7,891	(a)
1918	305,869	8,240,386	916,163	4,603,790	254,299	$1,031,789
1919	55,322	1,796,863	309,834	1,182,528	123,899	369,964
1920	94,000	2,385,000	416,000	1,551,000	257,000	540,000

(a) Value of ore containing 5 to 10 per cent. of manganese included in figures for ore containing 10 to 35 per cent. Figures not separable.

MANGANIFEROUS SILVER ORE SHIPPED
(In long tons)

Year.	Arizona.	Colorado.		Nevada.	New Mexico.
		For Fluxing.	For Other Purposes.		
1913	.....	49,753	.....	.....	.....
1918	(a)10,854	24,931	99,110	80,096	475
1919	(a) 1,964	29,769	11,055	77,815	250
1920	(a) 345	34,661	11,056	95,142	541

(a) Ore containing more than 35 per cent. of manganese sent to makers of manganese alloys not included.

The following table shows the receipts from the principal sources of supply for the past 15 years, in long tons:

	Cuba.	Brazil.	Russia.	India.
1906	.....	30,260	13,805	154,180
1907	.....	52,922	1,000	95,300
1908	.....	17,150	250	143,813
1909	.....	35,600	14,486	145,140
1910	.....	53,750	33,120	140,965
1911	.....	41,600	19,103	106,580
1912	.....	81,580	83,334	128,645
1913	.....	70,200	124,337	147,587
1914	.....	113,924	52,681	103,583
1915	5,141	268,786	.....	36,450
1916	30,563	471,837	.....	51,960
1917	44,511	512,517	.....	48,975
1918	82,974	345,877	.....	29,275
1919	35,320	246,592	6,916	9,200
1920	8,247	421,523	18,762	71,238

MANGANESE ORE AND OXIDE IMPORTED INTO THE UNITED STATES (a)
(In long tons)

Country from Which Imported.	1919.		1920.	
	Quantity.	Value.	Quantity.	Value.
Africa	1,388	$19,157	31,927	$123,415
Argentina	2,305	86,547	5,500	275,000
Australia	548	26,365	.....	.....
Brazil	246,592	7,177,071	421,523	8,833,493
British India	9,200	254,971	71,238	551,660
Canada	582	16,926	828	28,509
Chile	411	13,950	12,563	312,794
China	1	30	3,383	126,648
Colombia	10	969	.....	.....
Costa Rica	9,988	351,237	2,413	60,325
Cuba	35,320	1,433,202	8,247	266,744
Czecho-Slovakia	.....	.....	1,874	58,602
Ecuador	20	641	.....	.....
England	9,470	1,066,741	7,049	243,564
France	.....	.....	188	48,076
French Oceania	.....	.....	7,510	75,316
Germany	.....	.....	11	3,209
Hongkong	1,265	27,940	9,520	207,441
Japan	651	39,039	474	36,672
Mexico	6,295	266,307	2,925	55,449
Panama	2	76	.....	.....
Portugal	400	31,100	.....	.....
Russia	6,916	296,915	18,762	858,804
Turkey in Europe	2,000	120,000	1,000	65,000
Venezuela	.....	.....	2	111
	333,344	$11,229,184	606,937	$12,230,922

(a) Compiled from figures furnished by the Bureau of Foreign and Domestic Commerce.

Supplies of Ferromanganese

Ferromanganese production by American blast-furnaces in 1920 was the largest for any peace-time year and was only exceeded by the war record in 1918, according to the blast-furnace returns of the *Iron Age*. The 1920 total was 282,681 gross tons as compared with 179,029 onst in 1919 and with 345,306 tons in 1918, the largest previous output. In 1913 the production was 119,495 tons, confined largely to that of the United States Steel Corporation.

The spiegeleisen production last year was low at only 103,448 tons, but higher than the 1919 output, which was 65,391 tons. Last year's production was about the same as the 1913 and 1914 returns.

FERROMANGANESE AND SPIEGELEISEN OUTPUT IN THE UNITED STATES—GROSS TONS (a)

	Ferro-manganese.	Spiegel-eisen.	Total.	Average per Month.
1913	119,495	126,081	245,576	20,464
1914	106,083	100,365	206,448	17,204
1915	146,542	93,282	239,824	19,985
1916	208,389	197,518	405,807	33,817
1917	257,834	188,852	446,686	37,222
1918	345,306	249,002	594,308	49,525
1919	179,079	65,391	244,470	20,372
1920	282,681	103,448	386,129	32,346

(a) *Iron Age.*

The monthly output of ferromanganese in 1920 was 23,557 tons per month, which has been exceeded only in 1918 at 28,775 tons. Despite heavy reductions in pig-iron output in the closing months of 1920, the ferromanganese production was practically steady. The spiegeleisen output in 1920 was at the rate of only 8620 tons per month, which, though in excess of the 1919 rate of 5449 tons per month, was far below the war record of 1916, 1917 or 1918.

Available supplies throughout 1920 were fairly steady at around 28,000 tons per month and compared with 30,700 tons per month in 1918 and 25,400 tons per month in 1917. In 1919 these were only 17,420 tons per month.

Imports of British alloy were larger last year than at any time since 1916, or 4938 tons per month, as compared with 7577 tons per month in 1916. In 1913 they were 10,672 tons per month.

Exports of the American alloy do not expand in proportion to the supply, having been no larger in 1920 than in 1919 or 1917.

Prices.—Monthly quotations on ferromanganese are given in the following table:

	1914.	1915.	1916.	1917.	1918.	1919.	1920.
January	$ 36.00	$ 68.00	$110.00	$175.00	Government	$190.00	$147.00
February	38.00	100.00	140.00	210.00	Control	160.00	160.00
March	37.00	100.00	175.00	270.00	Price,	140.00	172.50
April	38.00	100.00	175.00	325.00	$250.00	120.00	191.50
May	38.00	100.00	175.00	400.00	.....	110.00	200.00
June	37.50	105.00	175.00	400.00	.....	110.00	200.00
July	27.50	103.00	175.00	400.00	.....	110.00	200.00
August	100.00	105.00	170.00	375.00	.....	105.00	187.00
September	80.00	110.00	164.00	360.00	.....	100.00	170.00
October	66.00	105.00	160.00	300.00	.....	105.00	160.00
November	68.00	100.00	155.00	250.00	.....	112.50	155.00
December	68.00	100.00	162.50	245.00	.....	123.08	125.00
Average	54.58	99.67	161.37	309.17	250.00	132.16	172.33

Manganese in Foreign Countries

Argentina.—There are two operating manganese mines in Argentina, which have been worked for two years. Both mines are in the Santiago desert country in the Province of Santiago del Estero. The production of one mine for a period of 30 months was 6000 tons of high-grade ore. It may be interesting to state that no machinery is used in mining; labor is very cheap, 24 to 48 cts. per day of 8 hr. Transportation is accomplished by means of native two-wheeled carts drawn by eight horses and carrying 1½ tons of ore.

Brazil.—The richest manganese zone lies in the State of Minas Geraes about 300 miles from Rio de Janeiro. The largest of the mines

is the Mina de Morro, which furnished the United States large quantities of ore during the war. This mine was recently purchased by the U. S. Steel Corporation, and it makes the corporation independent concerning manganese. This mine has been operated for 18 years. The property is practically a mountain of ore and mining consists of dynamiting off the side of the hill and crushing the blocks into convenient size for handling. The ore contains from 48 to 50 per cent. manganese.

Russia, British India, and Brazil are the chief sources of supply of manganese, but, as Russia was cut off during the war and Great Britain took over the Indian production, Brazil found it advantageous to increase its production until in 1917, 532,855 tons, valued at 57,284,000 milreis, was exported, practically the entire output going to the United States. In 1918 exports fell off considerably, owing to the decreasing demands after the armistice, but recovered somewhat in 1920, when 453,737 tons of manganese was exported, 446,228 tons, valued at 39,135,000 milreis, going to the United States.[1]

The following table shows the exports for several years past.

Year.	Metric Tons.
1910	252,958
1911	173,941
1912	154,870
1913	122,300
1914	183,630
1915	288,671
1916	503,130
1917	532,855
1918	393,388
1919	(a)250,550
1920	453,737

(a) U. S. imports from Brazil.

China.—Around the city of Canton manganese deposits are very common. These deposits are large and the ore of good quality. High freight-rates make profitable mining out of the question at present. Under favorable shipping conditions these deposits would be very valuable.

The Yuseng Manganese Mining Co. of Chang Sha has abandoned its plan to reduce manganese ore in China for home consumption.

Cuba.—Practically all the ore mined in Cuba is of rather low grade on the old standard of comparison. Very little runs over 40 per cent. manganese. During the period of the war Cuba was one of the important sources. Some modern treatment plants have been erected. The principal mines are located in Oriente, Santa Clara and Pinar del Re provinces.

Great Britain.—There is a small production of high-grade manganese ore in Great Britain, but the country is a very large importer to supply its steel industry, taking nearly all of the Indian output as well as large

[1] *Comm. Rept.*

supplies from other sources. The following table gives the British imports of manganese ore.

BRITISH IMPORTS OF MANGANESE ORE IN LONG TONS

	Total.	Average per Month.
1913	601,177	50,098
1914	479,435	39,953
1915	377,324	31,443
1916	439,509	36,625
1917	331,264	27,605
1918	365,606	30,467
1919	265,800	22,150
1920	452,613	37,718

India.—The manganese-bearing districts form a belt that extends from Baroda on the west coast across northern India nearly to Calcutta on the east, a distance of nearly 700 miles. The orebodies are lenses and layers. The largest single deposit has the form of a shallow trough. It is 1¾ miles long and 45 to 50 ft. thick, and has yielded over 725,000 tons of ore. The total production of India up to 1916 was 8,748,000 tons.

WORLD'S PRODUCTION OF MANGANESE ORE (a)
(In metric tons)

Year.	Austria-Hungary.	Belgium.	Bosnia. (b)	Brazil. (d)	Canada.	Chile. (d)	Cuba.	France.	Germany.	Greece.	India.
1906	20,577	120	7,651	121,331	84	35	(d) 13,997	11,189	52,485	(d) 9,200	379,231
1907	24,954	2,100	7,000	236,778	1	(c)	30,486	18,200	74,683	10,000	916,770
1908	27,257	7,130	6,000	166,122	*Nil.*	1	1,492	15,865	67,692	10,750	685,135
1909	29,966	6,270	5,000	240,774	*Nil.*	(c)	2,976	9,378	77,177	5,374	654,974
1910	28,964	*Nil.*	4,000	253,953	*Nil.*	(c)	6,393	7,925	80,559	41	813,761
1911	30,713	*Nil.*	3,600	213,000	5	(c)	10,324	6,036	87,297	733	681,018
1912	23,306	*Nil.*	4,650	154,870	68	(c)	10,807	5,576	92,474	7,719	643,205
1913	35,549	*Nil.*	4,700	122,300	*Nil.*	(c)	11,589	7,732	330,797	556	828,089
1914	(f)11,413	*Nil.*	4,120	183,630	25	(c)	9,871	6,393	(c)	558	693,824
1915	(c)	500	10,422	288,671	182	(c)	9,145	10,324	(c)	408	457,668
1916	(c)	3,870	22,674	503,130	868	(c)	33,653	10,807	(c)	3,600	655,592
1917	(f)90,269	2,020	48,851	532,855	143	205	(d)45,223	11,589	(c)	*Nil.*	600,325
1918	(c)	2,610	(c)	393,388	447	3,046	(d)183,305	9,871	(c)	(c)	526,231
1919	(c)	*Nil.*	(c)	(c)	*Nil.*	448	(c)	4,815	(c)	(c)	543,582

Year.	Italy.	Japan.	New Zealand.	Portugal.	Queensland.	Russia.	Spain.	Sweden.	United Kingdom.	United States.
1906..	3,060	54,339	16	22	1,131	1,015,686	62,822	2,680	23,126	7,032
1907..	3,654	20,589	26	1,374	1,134	995,282	41,504	4,334	16,356	5,694
1908..	2,750	11,130	*Nil.*	.....	1,403	362,303	16,945	4,616	6,409	6,243
1909..	4,700	8,708	6	.....	613	574,938	7,827	5,212	2,812	1,614
1910..	4,200	11,120	5	.....	805	(d)668,050	8,607	5,752	5,554	2,294
1911..	3,515	9,787	1	6	1,000	(d)584,000	5,607	5,377	5,067	2,497
1912..	2,641	12,060	*Nil.*	6	313	(d)766,000	19,936	5,101	4,237	1,691
1913..	1,622	2,313	*Nil.*	*Nil.*	27	1,171,000	21,594	4,001	5,480	4,113
1914..	1,649	17,076	*Nil.*	*Nil.*	6	737,300	(c)	3,643	3,496	2,677
1915..	12,577	25,870	*Nil.*	(c)	203	(g) 31,980	14,328	7,607	4,716	9,767
1916..	18,147	7,874	*Nil.*	(c)	653	(g)120,000	14,178	8,894	5,223	31,978
1917..	24,532	51,366	*Nil.*	(c)	21	(c)	57,474	19,873	10,104	131,475
1918..	31,896	29,759	*Nil.*	(c)	1,320	(c)	77,714	16,570	17,737	310,763
1919..	30,841	9,555	*Nil.*	(c)	20	(c)	66,685	12,278	12,272	56,210

(a) Official statistics. (b) Includes Herzegovina. (c) Statistics not available. (d) Exports (e) Estimated. (f) Hungary. (g) Shipments from Tchiaturi district; mostly held at port for lack of shipping.

Japan.—The expansion of the shipbuilding industry and other iron and steel industries during the war brought about a greatly increased demand for manganese which led to much prospecting and development.

Russia.—The manganese ore produced in Russia has been mined in three districts: Tchiaturi, in the central part of the Caucasus; Nikapol, on the Dnieper River, a short distance north of the Black Sea; and the central part of the Ural Mountains. Since 1880 the production has been very large. Before the war for many years Russia's output averaged over half a million tons yearly. The reserve of high-grade ore is estimated at 100,000,000 tons of ore running from 53 to 54 per cent. manganese and low in silica and phosphorus. At present the industry is in a state of stagnation.

Costs of Producing Manganese

The present average costs of necessary manganese run from $8 to $20 per ton depending on conditions. The high cost of producing manganese ore during the war still continues. Marked decline in the cost of certain supplies was noticeable in 1920, but the cost of rail transportation increased, particularly in the United States and Brazil, though ocean freights declined somewhat. The cost of transportation of ores is therefore more favorable to foreign than to the domestic supply.

The average pre-war cost of delivering manganese ore in American ports was 17.3 cts. per unit for Brazilian, Indian, and Russian ores, being 17.2, 17.1 and 17.6 cts. per unit, respectively. Some time will probably elapse before such cost of delivery will again obtain, and meanwhile the present high cost of transportation on American railroads will seriously curtail domestic production. The interest in domestic manganese deposits following the sudden rise in price was both prompt and extensive, and although not of material importance except in a few favored localities, it demonstrated that despite the loss sustained during the war period, many are still disposed to try their fortunes in the business of producing manganese under reasonably favorable conditions. The mining of manganese from domestic deposits will without doubt be continued indefinitely in such old producing localities as Batesville, Ark., and Butte and Philipsburg, Mont., and the manganiferous iron producing districts of Colorado, Minnesota, and Nevada.[1]

[1] W. R. Crane *Eng. Min. Jour.*, Jan. 22, 1921.

MICA

By J. Volney Lewis

With strong demand and good prices, the mica industry was prosperous during the first three quarters of 1920, but the year did not end with the promise with which it opened. During the earlier period the automobile industry was at its height, with its great demand for mica insulation in condensers, spark plugs, starters and generators. There was also a rapidly expanding market for electric household appliances and for small motors and generators, hence the prices of electrical grades ruled higher than during the preceding year. For similar reasons a like condition obtained in the market for phonograph discs. The response is seen in the increased domestic production and greatly increased imports.

With the general industrial decline during the latter part of the year, the demand fell off rapidly, surplus stocks, both domestic and imported, accumulated, and prices dropped 10 to 20 per cent. in the various grades. Hence the year, which opened with increased activity in mining, closed with greatly restricted production, and many operations were shut down during the last quarter. Demand in European markets sustained the prices of Indian mica for a time after the decline had set in in the United States.

Dealers complain that the domestic supply of mica is uncertain and limited and that the grading is both unsatisfactory and lacking in uniformity. In no other country is mica so carefully and so uniformly graded as in India. Increased mining activity and production during the greater part of 1920 are reported from both North Carolina and New Hampshire, which together furnish about 80 per cent. of the domestic supply.

Scrap Mica.—During the active period of 1920 scrap mica also shared in the prosperity that arises from strong demand and high prices. From a former level of $12 to $15 a ton, domestic prices ranged as high in some cases as $45 and $50 a ton, and were maintained about $30 as late as the first of November. The demand for the scrap, when ground to suitable degrees of fineness, comes largely from the roofing trade. It is also used in the manufacture of phonograph records, automobile tires, hard-rubber composition, wallpaper, and lubricating material.

A novel and interesting development of the year has been the recovery of scrap mica from kaolin-washing. One company, mining kaolin in the chief mica district of North Carolina, reports the production of about

400 tons of good scrap mica from this source—a quantity almost equal to that of all the mica mines of the region. Formerly this mica went with the tailings into the river and was lost.

Imports and Exports

A great increase was recorded in imports of mica in 1920, as compared with 1919. The quantity of uncut mica imported was 1,447,208 lb., valued at $1,298,342, an increase of 64.9 per cent. in amount and 46 per cent. in value over the preceding year. The average monthly imports during the earlier months were much greater than in the later months, but the difference in average value is slightly the reverse; that is, the later and smaller shipments were worth more than the larger quantities entered during the earlier months. Since prices were changing but little, this shows an increased proportion of the higher grades and larger sizes in the later imports.

Cut mica was imported to the value of $2,176,210 in 1920, as against $743,346 in 1919, an increase of 193 per cent. In the later months of the year the average value per month was nearly double that of the first half, which agrees with the figures in the preceding paragraph in pointing to an increased proportion of the higher-priced products in the later months.

This change in the character of imports is due chiefly to the dominating influence of Indian mica, which furnished much the greatest contribution to the total. Formerly all mica from India had to be marketed through London. The recent removal of this restriction has had the effect of bringing to the United States much high-grade mica that formerly went to other markets.

Good mica has been supplied in increasing amounts in recent years from Brazil and Argentina, and in smaller quantities from South Africa, China, Guatemala, and Mexico. At the same time the proportion of the whole supplied by Canada has steadily declined. The sources of the chief imports in 1919 were as follows: India, 40 per cent.; Brazil, 26 per cent.; Argentina, 15 per cent.; Canada, 14 per cent.; and 5 per cent. from all other sources.

Mica exports, chiefly in manufactured form, amounted to $316,169 in value in 1920, as compared with $109,348 in 1919, an increase of 189 per cent. The United States is much the greatest mica-consuming country, and the total value of mica exports is only about 9 per cent. of that of the imports.

Prices

The following table shows the approximate changes that occurred in the prices of clear mica in the last quarter of 1920. The first part of the

table gives New York prices, based on the grading of India mica; the second part gives the prices received by the miners in one of the mica districts of North Carolina. The sizes are only approximately the same, hence the figures in the two parts of the table are not strictly comparable.

CHANGES IN MICA PRICES IN 1920

F.o.b. New York, India Grading.			Franklin, N. C., at Mines.		
Sizes.	First Three Quarters.	Last Quarter.	Sizes.	First Three Quarters.	Last Quarter.
5	$2.00	$1.75	2×2	$1.15	$0.85
4	4.00	3.25	2×3	1.65	1.25
3	5.75	5.00	3×3	2.10	1.75
2	7.00	6.50	3×4	2.50	2.25
1	9.00	8.00	3×5	2.75	2.50
A1	14.00	10.00	4×6	3.75	3.50
			6×6	6.50	6.00

Mica in Foreign Countries

British India.[1]—Official statistics for the fiscal year ending Mar. 31, 1919, show a decrease in quantity and an increase in value, due largely to the strength of the demand for the superior grades. Exports amounted to 2,800 tons, a decrease of 15 per cent. as compared with the preceding year, but still 14 per cent. above the pre-war average. The value of exports increased 4 per cent. to $2,915,034—all to the United Kingdom, direct exports to other countries being prohibited throughout the year.

India furnishes more than half the world's supply of mica. The mineral is widely distributed, but the areas in which marketable mica occurs are few and strictly defined. The chief of these is a belt about 80 miles long and 12 miles broad in the northern part of the Hazaribagh district and extending into the adjoining districts of Gaya and Monghyr. The center of the industry is at Koderma, in the Hazaribagh district. Mica is also mined in the Nellore district, Madras Presidency, and in the provinces of Behar and Orissa, Bengal.

In most cases very primitive methods are used, and a mica mine or quarry presents the appearance of a huge rabbit warren, the workers burrowing from "book" to "book" by narrow passages, some of which are barely sufficient to admit a small boy. The lower levels are reached by rough bamboo ladders, and the excavated material is passed hand over hand from one coolie to another. Water is bailed in buckets in the same way, and during three months in the monsoon operations may be suspended altogether, the mica being under water. As the more accessible mica near the surface has been mined out, however, pumps and hoists

[1] *Comm. Rept.*, June 2, Aug. 23, 1920.

are gradually being introduced, and shafts 300 to 400 ft. deep are being operated in some mines.

The Government took over part of the field during the war and worked it as a State industry, in order to assure a constant supply.

There is every reason, says D. A. Hall,[1] to expect that India will retain its position as the most important mica-producing country. The great number of deposits offer almost every grade of muscovite required in the trade. The industry is well established and labor conditions are extremely favorable for the production of a commodity requiring such a large amount of hand labor before being ready for the market. It is true, however, that the richest and most easily accessible deposits have been mined out, and scientific methods must be applied to mining if production is to retain its former place.

Brazil.[2]—The imports of mica from South America prior to the war were practically negligible, but the war stimulus directed attention to Brazil and Argentina, both of which are known to have available deposits of mica of desirable quality and size. In Brazil, mainly in the contiguous states of Bahia, Goyaz, Minas Geraes, and Sao Paulo, the deposits are extensive and are now fairly accessible to railroads for transport to the ports. The mica is good and the better grades are considered equal to the best India mica. In the interior of Goyaz the natives have used it for window panes from prehistoric times.

From the large number of known deposits and the rapidity with which the industry responded to war demands, it would appear that Brazilian mica will play an increasingly important part in the mica markets of the world, particularly of the United States. It is important that buyers seek out the producers, however, who are not well advised as to the market requirements.

From 1902 to 1913 Brazil produced about 113 short tons of mica; in 1916, 59 tons; in 1917, 106 tons; in 1918 and 1919, estimated at 135 tons yearly. The State of Sao Paulo has exported mica as follows:

	Kilos.	Value, Paper Milreis.
1914	400	800,000
1915	19,183	22,520,000
1916	7,574	13,220,000
1917	10,771	63,664,000
1918	11,604	57,240,000

Argentina.[3]—Production of mica began in Argentina in 1908. Until recently production has been incidental and the development has been slight. Deposits are numerous, but are of special importance in the provinces of Cordoba, San Luis, and San Juan. Considerable shipments

[1] "Political and Commercial Geology." McGraw-Hill Book Co., New York, 1920, p. 385.
[2] *Eng. Min. Jour.*, Dec. 11, 1920; *Min. Jour.*, May 1, 1920; "Political and Commercial Geology," p. 384.
[3] *Suppl. to Comm. Rept.*, May 29, 1920; *Eng. Min. Jour.*, Dec. 11, 1920; "Political and Commercial Geology," pp. 383, 384.

have been made to the United States and to Europe, but the material received here has not been considered equal to Indian or Brazilian mica.

The following figures give the production for the last three years for which statistics are available:

	Metric Tons.	Value, Gold Pesos.
1916	5	3,882
1917	70	36,494
1918	214	184,217

Canada.[1]—Canadian phlogopite continues to supply most of the world's "amber mica," which is preferred for certain electrical uses. The mica occurs in dike-like bodies that are structurally somewhat similar to pegmatites. The chief associated minerals are pyroxene, apatite, and calcite, although in some deposits the mass is almost entirely mica. The enclosing rock is commonly limestone.

Scientific methods have been applied to the mining and preparation of a considerable part of the output. Reserves are large and Canada may be expected to maintain for many years its position as the principal source of amber mica. The Blackburn mine at McGregor Lake, Quebec, one of the few underground mica mines in the country, has reached the depth of 250 ft. on a slope of 60 degrees. The Wallingford mine, at Perkins, Que., is reported to have taken out some exceptionally large mica during the year, a great part of which was shipped to England.

In 1920 Canada produced 2150 tons of mica, valued at $368,297, as compared with 2754 tons, worth $273,788, in 1919—a decrease of nearly 22 per cent. in amount, but an increase of 34.5 per cent. in value. In 1919 over 80 per cent. of the total production of the Dominion came from Quebec. The greater part of Canadian mica is exported to the United States, but an appreciable quantity, especially the larger-size sheets, is sent to England.

Transvaal.[2]—Mica of the muscovite, or "white mica" variety occurs in commercial deposits in many granite pegmatites intrusive in the older granite-gneiss and schists of the Low Country. The mica belt, approximately 300 sq. mi. in extent, has been worked on a considerable scale since 1909, but until 1912 the nearest railway station was 120 miles distant. The opening in that year of the Selati railway, which crosses the belt, has given a great impetus to the industry.

The mica forms pockety deposits scattered irregularly through coarse pegmatite. The size of the nests or pockets is subject to extreme variation, in exceptional cases being measured by cubic yards. The workings are almost entirely open-cut, up to 50 ft. in depth, and all of them are still in the zone of weathering. An occasional shaft or incline is a little

[1] Prelim. Rept. Min. Prod. of Canada, Can. Dept. of Mines; *Can. Min. Jour.*, Aug. 20, 1920: "Political and Commercial Geology," pp. 382, 385.
[2] A. L. Hall, Union So. Afr. Geol. Surv. Memoir No. 13, 1920.

deeper, and one drift is 200 ft. long. The color is generally a pale delicate olive-green, but a pale brownish to nearly colorless variety is sometimes found.

The producers are advised to develop their projects with the major object of accumulating stocks for building up and maintaining an export trade in the medium and smaller sizes, which can be produced in satisfactory quality and quantity, and to take the few large sheets as lucky windfalls by the way. Practical trial is also recommended with a view to converting the large accumulations of waste into ground mica.

South Africa in 1918 produced 5 tons of mica, valued at $5767; in 1919, 3 tons worth $1796.[1] In 1920 only 1 ton was recovered.

Rhodesia.[2]—In the Lomagundi district an area of more than 40 sq. mi. on the western flanks of the Angwa River basin and 64 miles from the present railway terminus at Sinoia, but only a few miles east of the proposed Sinoia-Kafue railway, is mica-bearing. It is a well-watered bush country at a mean altitude of about 4000 ft. above sea-level.

The country rocks are mica schist and quartzite intruded by fine-grained porphyritic biotite granite and dikes of pegmatite. The dikes range from a few inches to 10 or 15 yd. in thickness and carry the "books" of mica (muscovite) in remarkably regular reefs or a succession of lenticles against the mica-schist walls. In some of the thinner dikes the mica follows only one wall. The books of mica lie at all angles, often touching one another, and even closely packed. Zones of mica also surround the "horses" of mica schist, which are thus a structure not unwelcome to the miner.

The books vary in size from 4 or 5 in. to as many feet, the majority probably being between 6 and 18 in. They are seldom more than 6 in. thick, and frequently half that. The color is commonly ruby or bottle-green, and some is clouded and silvery. Much of the mica is stained—near the surface deeply stained; but mining seems to show that staining diminishes 10 to 15 ft. down, and the mica becomes only slightly stained, spotted, or clear.

All workings are open-cut and do not yet exceed the depth of 35 ft. Much of the work is done with pick and shovel, the feldspar being decomposed to a clay and therefore easy to work. The pegmatite dikes are so close together that it is economical on some claims to take out together the foot-wall band of mica, the intervening mica schist, and the hanging-wall band of mica in the next dike. In other cases the two bands belonging to one dike are taken out together, or each band is worked separately.

It is estimated that 1½ lb. of trimmed mica is a good average yield

[1] *Comm. Rept.*, Sept. 22, 1920.
[2] H. B. Maufe, "Mica in the Lomagundi District, Southern Rhodesia." Southern Rhodesia Geol. Surv., Short Report No. 10, 1920.

from each hundredweight of mica won. The waste therefore is enormous Much of this waste is of marketable quality and could be converted into splittings for the manufacture of mica board, mica cloth, or mica paper, and other portions could be pulverized and sold as ground mica.

Rhodesia produced 6 short tons of mica in 1919, valued at $6545. In 1920 the production rose to 97 tons, valued at $122,410, according to the official reports of the Mines Department.

Madagascar.[1]—Very promising deposits of phlogopite, or amber mica, have been opened up in southeast Madagascar and active mining and exportation have begun on a considerable scale. The largest sizes run considerably above those on the London market, sheets 25 in. square, without a stain or crack, being reported. Several hundred natives are employed near the village of Ambatohabo, and mining has reached the depth of about 90 ft. with no indication of exhaustion of the deposit. The mineral is being used locally for the manufacture of fancy articles, such as trays, collar- and brush-boxes, cigar-boxes, fans, and sailor-hats entirely of mica, which the natives occasionally sport in town. Exports in 1920 amounted to 49.5 metric tons.

Queensland.[2]—Pegmatite veins containing mica in large crystals are known in many of the mining fields of northern Queensland, notably on the Einasleigh River, near Junction Creek, in the Etheridge Goldfield. Recent examinations of deposits on Rifle Creek, in the Cloncurry district, indicate that they are the most important thus far found in the State.

Roumania.—It is reported in a recent issue of *Commerce Reports* that rich veins of mica have been explored and are now being exploited in the district of Mehedintz, Roumania, by a company hastily created with a capital of 5,000,000 lei. In a relatively short time the company has produced 15 carloads of mica, which is valued at 1,000,000 lei per carload.

Statistics

PRODUCTION OF MICA IN THE UNITED STATES (a)

	Sheet Mica.		Scrap Mica.		Total Value.	Value of Imports.
	Pounds.	Value.	Short Tons.	Value.		
1910	2,476,190	$283,832	4,065	$53,265	$337,097	$725,823
1911	1,887,201	310,257	3,512	45,550	355,804	505,552
1912	845,483	282,823	3,226	49,073	331,896	755,584
1913	1,700,677	353,517	5,322	82,543	436,060	947,780
1914	556,933	278,540	3,730	51,416	329,956	629,484
1915	553,821	378,259	3,959	50,510	428,769	692,269
1916	865,863	524,485	4,433	69,906	594,391	1,071,356
1917	1,216,816	708,381	3,250	48,965	757,346	1,430,048
1918	1,644,200	731,810	2,292	33,130	764,940	1,541,129
1919	1,545,709	483,567	3,258	58,084	541,651	1,632,893
1920	.....	.....	.....	.....	.....	3,476,307

(a) U. S. Geol. Surv.

[1] *Min. Jour.*, Oct. 16, 1920, May 21, 1921.

[2] *Queens. Govt. Min. Jour.*, Oct. 15, 1920.

IMPORTS OF MICA INTO THE UNITED STATES[1]

	Unmanufactured.[4]		Cut, Split, and Mfd.[5]		Ground.		Total.
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Value.
1910	1,424,618	$460,694	536,905	$263,831	.....	$1,298	$725,823
1911	1,087,644	346,477	241,124	155,686	.....	3,389	505,552
1912	1,900,500	649,236	88,632	99,737	.....	6,611	755,584
1913	2,047,571	751,091	46,336[3]	191,924	290,757	4,765	947,780
1914	360,888	168,591	.....[2]	456,805	404,840	4,088	629,484
1915	433,822	240,449	.....	447,962	344,040	3,858	692,269
1916	703,832	421,856	.....	646,080	362,000	3,420	1,071,356
1917	656,391	414,823	.....	1,014,181	92,963	1,044	1,430,048
1918	741,429	658,576	.....	880,906	11,587	1,647	1,541,129
1919	877,592	889,538	.....	743,346	62	9	1,632,893
1920	1,447,208	1,298,342	.....	2,176,210	760	1,755	3,476,307

[1] Statistics from Bureau of Foreign and Domestic Commerce.
[2] From Jan. 1 to Oct. 3.
[3] Quantities not reported.
[4] Essentially trimmed sheets.
[5] Includes Madras square-shaped uncut sheets.

EXPORTS OF MICA FROM THE UNITED STATES
(Bureau of Foreign and Domestic Commerce)

	Unmanufactured.		Manufactured.	Total.
	Pounds.	Value.	Value.	Value.
1913	298,711	$14,175	$62,184	$76,359
1914	467,451	23,145	50,896	74,041
1915	54,183	5,118	39,033	44,151
1916	63,168	4,544	78,671	83,215
1917	.....	.....	.....	74,485
1918	.....	.....	.....	74,529
1919	.....	.....	.....	109,348
1920	.....	.....	.....	316,169

STATISTICS OF MICA IN CANADA[1]

	Production.		Exports.	
	Short Tons.	Value.	Pounds.	Value.
1913	.....	$194,304	817,152	$240,775
1914	.....	109,061	669,163	178,940
1915	.....	91,905	879,631	236,124
1916	.....	122,541	1,308,793	379,720
1917	.....	218,034	1,198,707	456,671
1918	747	271,550	866,000	410,000
1919	2,754	273,788	5,482,000	641,962
1920	2,150	368,297	.....	.....

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MOLYBDENUM

By W. Norman Bratton

No mines operated continuously during 1920 in the production of molybdenum alone. Molybdenum has passed through a period of inflated development when its principal consumption was in place of other metals which could not be obtained. The resumption of a demand is dependent upon uses that compete commercially with other metals used in tonnage products.

In this period of inflated development, the extraordinary prices led to numerous speculations and capital investments in properties that will not yield returns when the industry is upon a peace basis. With its numerous occurrences of molybdenum, Norway, by reason of its geographical position in relation to England and Germany and its neutrality during the war, received the highest prices for its output of molybdenum. As a result of these factors, it is probable that Norway has more capital invested than any other country.

The principal centers of demand were the United States and England. England contracted for the total output of Australia and for most of the output from Canada. Some of the Canadian output was shipped to the United States and France. In the future the chief center of demand will be the United States.

While the nations at war in Europe used molybdenum as a substitute, chiefly in high-speed tool steels, the largest consumption in the United States was a combination of less than 1 per cent. molybdenum in conjunction with or to replace the commonly specified alloys of structural alloy steels bearing nickel and vanadium. The production of about 50,000 tons of molybdenum steels has proved that this is the application which insures the future consumption of molybdenum in tonnage quantities.

Without a market and with immense reserves of ore, the molybdenum industry in the United States is actively engaged in fostering a recognition of the value of molybdenum steels. The United States alone has, at the present time, more than enough molybdenum to displace the nickel and vanadium in the alloy steels that bear these elements.

Market in 1920

The over-production of molybdenum has not been absorbed and at steel mills there is enough molybdenum for the manufacture of many thousand tons of molybdenum steel. The changes in the demand for molybdenum will vary with the fluctuations in the production of alloy

steels. At the beginning of 1920 there was an excellent prospect for a considerable output of molybdenum steel, but in the depression which followed, the effort to establish a tonnage consumption was futile.

Manufacturers in the United States became actively interested in molybdenum steel and the results of their investigations will lead to the adoption of molybdenum steel where an alloy steel is required. The extent to which a sound and consistent demand may be created will be measured by the effort put forth by the molybdenum industry in cooperating with steel mills and consumers of alloy steel to furnish metallurgical data for the economical application of molybdenum steel.

The demand for any steel that could be obtained during the first part of the year gave the manufacturers and consumers scant time to consider the use of molybdenum steel, and when some had started to carry on experiments in quantity production, the depression in all industries checked the tonnage prospect for the year. Time was then afforded for investigations in metallurgical laboratories, and the results have so far progressed that some of the largest automotive companies will announce in 1921 the use of molybdenum steel as a standard in their product. The market for molybdenum depends upon the general resumption of business, and when conditions are normal again and the surplus stocks are used up, the market is assured of a steady growth.[1]

Tariff.—In order to repay the producers of molybdenum during the period when large expenditures are necessary to place the uses and metallurgical information concerning molybdenum steel before prospective consumers, the producers in the United States petitioned the Government for a tariff.

Prices.—In the desire to liquidate inventories of concentrates and ferromolybdenum, offers were merely nominal and bids for acceptance were at a still lower figure. Even with the marked concessions that followed, the volume of business was small.

PRICE OF CONCENTRATES

United States:	Jan. 1, 1920, 75 to 85 cts. per lb. of MoS_2 in 85-per cent. concentrates.[2]
	Jan. 1, 1921, 85 cts. per lb. of MoS_2 in 85-per cent. concentrates.[3]
England:	Jan. 1, 1920, 80s. per unit of MoS_2 in 85-per cent. concentrates.
	Jan. 1, 1921, 75s. per unit of MoS_2 in 85-per cent. concentrates.[4]

PRICE OF FERROMOLYBDENUM

United States:	Jan. 1, 1920, $3.00 to $3.50 per lb. of Mo contained.[5]
	Jan. 1, 1921, 2.25 to 2.75 per lb. of Mo contained metal for standard grades carrying from 50 to 60 per cent. molybdenum with low sulphur, phosphorus and arsenic.[6]
England:	Jan. 1, 1920, 12s. per lb. of molybdenum contained in 70 to 80-per cent. ferromolybdenum.
	Jan. 1, 1921, 9s. per lb. of molybdenum contained in 70 to 80-per cent. ferromolybdenum.[7]

[1] *Cf. Eng. Min. Jour.*, **111**, 147, (1921).
[2] *Chem. Met. Eng.*
[3] *Eng. Min. Jour.*
[4] *Min. Jour.*
[5] *Chem. Met. Eng.*
[6] *Eng. Min. Jour.*
[7] *Min. Jour.*

Metallurgical Status

Technical developments for the use of molybdenum in structural steels and the metallurgical solution of the problems in connection with quantity production have been promoted in the United States. Arnold and Ibbotson presented an elaborate paper on the efficiency of high-speed tool steels before the May, 1919, meeting of the Iron and Steel Institute, England, wherein a molybdenum high-speed tool steel ranked first in cutting efficiency. Discussions before the technical societies in the United States have been upon structural molybdenum steels.

Following the first employment of molybdenum as an added element to nickel-chrome steel for the crankshafts of Liberty motors and to nickel steel for light armor-plate, a series of chrome-molybdenum steels, with physical properties better than chrome-vanadium steel, were developed in four carbon ranges that provided for all the diverse specifications of a complicated unit such as an automobile.

In manufacturing economy, chrome-molybdenum steels effect a greater saving than other alloy steels fabricated into finished parts that have been forged or machined. In the treatment at the steel mills, the molybdenum is added to the bath of an open-hearth furnace before the slag has formed and the proportionate amount of molybdenum left in the steel when the melt is finished averages about 90 per cent. In rolling, as in forging, the oxide scale parts most easily from the steel, so there are less surface defects therefrom. In the other mill operations, molybdenum steel processes with equal facility. In heat-treatment the steel may be subjected to a very wide range of temperature without impairing the physical properties.

The field for alloy steels has been materially broadened by the use of molybdenum steel in sheets to afford a greater strength in sheet-metal parts of automobiles such as frames, axle-housings, tire-rims, disc or wire wheels, and other parts where the lightest weight consistent with strength is economical.

Molybdenum has a progressive effect in steel such that the addition of higher percentages up to 1 per cent. will result in better physical properties, or heat-treated to show the same tensile strength as other alloy steels will have a better ductility and toughness. This property is so pronounced that the addition to steel of less than 0.2 per cent. of molybdenum develops a remarkable increase in strength and toughness. The analyses as a consequence are varied to produce molybdenum steels as cheaply as other alloy steel where the first cost of the steel is a consideration. This factor coupled with the saving in the cost of forging and machining is a dual advantage which assures an increased consumption of molybdenum steel to displace the other alloy steels.

Molybdenum Resources

Australia.—Characteristics peculiar to Australian ore are the association of molybdenite with tin and bismuth and the occurrence of the ore deposits in pipe formations. The ore seldom occurs in veins that may be profitably mined.

There are no present mines with estimated resources of commercial ore equivalent to the noted mines in Canada and the United States. In many instances the ore yields coarse flakes of molybdenite that are recovered without oil-flotation. The ore that has been mined in Australia seems to be higher grade than that of any other large producing country. A good percentage of the total output of molybdenite has been extracted from ore deposits that do not have equipment to mill the ore by flotation methods.

New South Wales.—Molybdenite interests prominently mentioned in the Annual Report of the Department of Mines, New South Wales, for 1919 are:

Allies Consolidated Molybdenite Syndicate
*Glen Innes Molybdenite and Bismuth Syndicate
Kingsgate Molybdenite, N. L.
Mammoth Molybdenite Mines, N. L.
*Mount Barney Molybdenite Property
Mount Boorolong Molybdenite Mines, N. L.
*Mount Tennyson Molybdenite Mining Co.

Queensland.—A report by E. Cecil Saint-Smith on the deposit at the Kitchener Molybdenite mine near Khartoum estimates a large tonnage of molybdenite in a 3 to 4-per cent. orebody that averages not less than 4½ ft. wide.[1]

The Wonbah Molybdenite Mining Co., Ltd., operates at Wonbah, a siding on the railway from Bundaberg to Mount Perry. J. H. Reid notes that the pipe, which is almost cylindrical, varies from 42 to 60 ft. in diameter between the surface and a depth of 200 ft. The outer zone of the pipe is the working area, being richer in molybdenite. The working face is 16 ft. across, leaving a central core standing about 25 ft. in diameter, which is relatively poor. The ore going to the mill averages 0.8 per cent. MoS_2. Recently 30 to 40 tons of ore have been treated per day (three shifts).[2]

Victoria.—The Standard Molybdenite mine in the Everton field is 14 miles from Wangaratta, Victoria. In June, 1917, the Everton Molybdenite Syndicate acquired the lease. The ore on a dump assays about

[1] *Queens. Govt. Min. Jour.*, May 15, 1917.
[2] *Eng. Min. Jour.*, Nov. 13, 1920.
* Mill not completed.

4 per cent. and is treated by an oil-flotation mill that has a capacity of 21 cwt. per hr. A face of ore has been exposed over 20 ft. wide.[1]

Canada.—The demand for molybdenum created during the war and the high prices led to an intensive investigation of every property that had even a meager promise of production. The Department of Mines built a concentrating mill at Ottawa which treated small quantities of ore delivered there and the International Molybdenum Co. of Orillia, Ont., also operated a custom mill.

The Moss mine, 3 miles from Quyon, Quebec, a station on the Waltham branch of the C. P. R. 33 miles from Ottawa, is owned by the Dominion Molybdenite Co., which superseded the Canadian-Wood Molybdenite Co. E. M. Wilson states that the molybdenite deposits are known as deposits number 1 to 5 in the order of their importance. The No. 1 deposit is exposed on the faces and bottom of the No. 1 pit and is approximately 50 ft. wide and 200 ft. long. The No. 2 deposit is approximately 150 ft. long and from 5 to 25 ft. wide. Deposits No. 3 and 4 are smaller masses, 15 and 5 ft. in width respectively. Deposit No. 5 is a small irregular mass 10 ft. in diameter. It is probable that at the time the writer (E. M. Wilson) made his examination of the deposits, the average molybdenite content of the ore exposed at the bottom of No. 1 pit did not exceed 0.75 per cent. and that the average content of the ore in the exposed surface of the No. 2 deposit was probably less than 0.5 per cent.[2] A 150-ton mill is installed on the property to treat the ore.

The Renfrew Molybdenite Mines, Ltd., own the Belgian mine, located on Mount St. Patrick 11 miles from Ashdod Station on the Kingston and Pembroke railway.

The average run of ore analyses less than 1 per cent. molybdenite and a 35-ton mill is installed to treat the ore. The occurrence of the orebodies, in one place 30 ft. wide, extends along a contact deposition indicated for some hundreds of feet by present underground workings.

Norway.—When Germany could not obtain the necessary metals for alloy steel, Norway was the only country accessible and molybdenum was practically the only metal that Norway could supply for this purpose. The development was logical and stressed to maximum production by contracts with the British Government for the entire output of the Norwegian mines.

An amalgamation of 15 Norwegian molybdenite companies is at present directed by the Norske Molybdenprodukter A/S.

In a translation of an article[3] by Dr. Eugene Otto Falkenberg in *Teknisk Ukeblad* on "Molybdenum Mines in Norway" it is stated that

[1] *Chem. Eng. Min. Rev.*, Sept. 5, 1920.
[2] *Can. Min. Jour.*, Mar. 1, 1918.
[3] *Eng. Min. Jour.*, June 18, 1921.

the downward dimension seems to be quite limited and there is probably no molybdenite mine over 100 ft. deep.

The following information is taken from a paper by E. R. Woakes on "Molybdenum in Norway:"[1]

The Knaben No. 1 mine owned by the Blackwells Development Corporation, Ltd., is located in the district of Fjotland, a day's journey by cart from Flekkefjord. In the upper workings the mineralization occurred over a width of 30 ft. with some fine veins of solid mineral. Outside the main orebody the fissure is badly defined and erratic, and there is very little impregnation of the country rock with molybdenite. The plant consists of the usual crushing machinery and one Elmore unit.

The Kvina mine owned by A/S Kvina Gruber is located a mile north of Knaben No. 1. The ore occurs at the contact of the quartz and granite and also at the quartz and pegmatite contacts, and there is a good deal of impregnation of the granite. Masses of molybdenite-impregnated rock often occur in the footwall, apparently far removed from any contact. The concentrator is well designed and contains two Elmore units. The ore is low grade, probably about 0.3 per cent. or even less.

The Dalen mine in the Telemarken district owned by A/S Dalen Gruber is located at the western end of Lake Bandaks. The Dalen ore deposit consists of a flat "hungry-looking" quartz vein in a fine-grained silicious slate. The quartz vein varies in width from 3 ft. to a few inches, and outcrops on the mountain side for a length of 200 m. It dips slightly to the west and does not extend into the mountain, but peters out to a mere stringer in a length of 200 ft. The concentrator contains two Elmore units.

United States.—Summit and Lake counties in Colorado are the premier mineral field in the world for reserves of molybdenum ore available. The characteristics of an immense deposit at Climax, Colo., have not been duplicated elsewhere in extent and marked uniformity of the ore throughout the entire mass, which does not vary appreciably from 0.8 per cent. except in a few places where faulting has resulted in an enrichment.

Arizona.—The Standard Minerals Co. have a property 19½ miles southeast of Kingman, Ariz., and have erected a 40-ton mill. The molybdenum occurs as a low-grade ore in a series of veins some of which have been encountered at a depth of 400 ft. Their prospectus states that one of the veins averages over 7 ft. in width.

The Mammoth and Collins mines adjoin each other 3 miles west of Mammoth, Ariz. F. W. Horton reports in "Molybdenum: Its Ores and Their Concentration" that the mines are situated on two roughly parallel veins that are about 600 to 700 ft. apart. The veins vary greatly in width

[1] *Inst. Min. Met.*, Jan., 1918.

both along the strike and the dip. The Mammoth vein is one or two inches to 60 ft. wide. One part that has been explored averages 13 to 15 ft. in width for a horizontal distance of about 750 ft. Work on the Collins vein indicated that it has an average width of 12 to 15 ft. The writer assumes that as a whole the orebodies contain 1 to 2 per cent. of the mineral wulfenite.[1]

Colorado.—Excerpts from an article by H. L. Brown and M. W. Hayward on "Molybdenum Mining at Climax, Colorado" in the *Engineering and Mining Journal* for May 18, 1918, are as follows:

"An area approximately 1000 by 800 ft. has been completely blocked out and contains over 6,000,000 tons averaging 1 per cent. molybdenum sulphide. (As shown by longer operation, this estimate seems to be a little too high; 0.8 per cent. is probably nearer the actual content.) Another tunnel has been started 200 ft. below these workings, and shows ore of the same grade and character. The mineralized area of this tunnel level probably will be nearly double that of the upper level."

The Climax Molybdenum Co. has installed a mill and equipment with a present capacity of 1000 tons of ore a day, which is sufficient to provide more than 1500 tons of molybdenite a year.

The Molybdenum Products Corporation started production upon an extension of this deposit, but closed down after a short period of operation.

Present explorations have blocked out millions of tons of ore and, so far as present surface indications are determinable, extensions which have been developed will substantially increase the grand total of molybdenum ore available. Frank L. Hess of the U. S. Geological Survey reports in *Mineral Resources of the United States*, 1918: "So far as it is already explored, the deposit can probably supply 100,000 tons of elemental molybdenum." This quantity of elemental molybdenum is equivalent to the molybdenum content of more than 20,000,000 tons of ore.

The Vanadium Corporation of America has acquired the Urad mine, formerly the property of the Primos Chemical Co., located 14 miles from Empire, Colo. The ore-bearing bodies consist of three veins of low-grade ore, the general strike of which crosses the range of the mountain. The veins are known as veins No. 1, No. 2 and No. 3. Vein No. 1 at its intersection with the upper tunnel is 3 to 4 ft. across. Vein No. 2 as exposed by 1000 ft. of development work has an average width of perhaps 2 ft. Vein No. 2 at its intersection by the upper tunnel showed 10 ft. of ore.[2]

In the spring of 1918 a 150-ton mill was installed to treat the ore.

New Mexico.—The Molybdenum Corporation of America acquired

[1] *Bull.* 111, U. S. Bur. of Mines.

[2] *Bull.* 111, U. S. Bur. of Mines.

the R. & S. Molybdenum mine located 8 miles up the Red River from Questa, N. Mex., and about 27 miles from the San Luis Southern Railway station at Jarosa, Colo.

An article by Esper S. Larsen and Clarence S. Ross of the U. S. Geological Survey on the above mine is published in *Economic Geology*, November, 1920. Excerpts follow:

A tunnel has been driven for 300 ft. along one of the southern-most group of veins exposed on the property and in places has been stoped to a height of 60 ft. The ore as it comes from the stopes is said to average about 2 per cent. of MoS_2. In the 300-ft. tunnel the mineralized zone has been rather constant in its characteristics, varying in width from 4 to 6 ft. The 300-ft. tunnel exposes several thousand tons of ore and the chance of considerable more ore in the vein prospected by the tunnel and in some of the other veins seems good. The equipment at the mill consists of a jaw-crusher, ball mill, classifier, and flotation plant.

Alaska.—The Alaska Treadwell Co. owns a property on the northwest end of Prince of Wales Island, 180 miles north of Treadwell, Alaska. One of their engineers, F. W. Bradley, reported in October, 1918: "The vein on this property outcrops for a length of over 500 ft. with an average width of 5 ft. and an average assay of 1 per cent. molybdenite. A tunnel being driven on the strike of the vein has now advanced a distance of 320 ft. and has developed the vein for an average width of 7.7 with an average assay of 1.89 per cent. MoS_2. The average of the surface and underground showings is a width of 5.85 ft. assaying 1.58 per cent. MoS_2, indicating 100,000 tons of which 6270 tons is positively blocked out, with an average of 2.28 per cent. MoS_2.

Molybdenum Production

Australia.—Queensland ranks first in production, with New South Wales second and Victoria third.

New South Wales.—A large part of the tonnage of molybdenum mined in New South Wales has come from leaseholds in the Deepwater Division and the Glen Innes Division.

Production figures taken from the annual report of the Department of Mines for 1919 are as follows:

	Tons of Ore.	Tons of Concentrate.	Value.
Allies Consolidated Molybdenite Syndicate	200	18.7	£9440
Kingsgate Molybdenite, N. L.	2506	.....	2833
Mammoth Molybdenite Company, Ltd	4424	9.0 about	3150
Mount Boorolong Molybdenite Mines, N. L.	500	3.0 about	1200

Queensland.—The largest output of molybdenite has come from the Chillagoe and Mount Perry mineral fields.

The Wonbah Molybdenite Mining Company, Ltd., is the premier producer of molybdenite in Queensland and apparently also in Australia.[1]

The following figures, in long tons, give the output of the mine for 1918 and 1919:

Year.	Crude Ore.	90 Per Cent. MoS_2 Concentrates.
1918	2435	13.95
1919	6026	41.75

Victoria.—Mining has been steadily carried on at the Standard Molybdenite mine, parcels of picked ore being sold from time to time. The mill was put into commission in March, 1920. After May 26, 250 tons of ore was treated, giving approximately 8 tons 2 cwt. of concentrates assaying 85 per cent. MoS_2.[2]

Canada.—The total production in 1919 representing the quantity of MoS_2 contents of the concentrates for which payment was made amounted to 83,002 lb., valued at $69,203, or an average of about 83.4 cts. per lb. The total production in 1918 representing the MoS_2 contents of the concentrates produced for which payment was made amounted to 378,029 lb., which at $1.15 per lb. would have a total value of $434,733. The total shipments of concentrates as stated by the producers were in 1919, 46.0 tons, valued at $69,203, and 6783 tons of ore was treated at the concentrating plants. In 1918 the total shipments of ore and concentrates were 461.4 tons, valued at $428,807, and there was 33,935 tons of ore treated at the concentrating plants.

Canadian molybdenum properties did not operate in 1920.

Norway.—Until the end of 1917 there were only three considerable producers, namely:

1. Knaben mines in Tjotland, with a total production of about 275 metric tons of pure MoS_2.

2. A/S Kvina mines, in Tjotland, with 150 metric tons of pure MoS_2.

3. A/S Dalen mines, in Telemarken, with 100 metric tons of pure MoS_2.

The quantity of concentrate delivered by other mines was small. The principal production outside of the three first-named mines came from three others:

4. Tjaerdalskampen, in Saltdalen, production in the 80's about 10 metric tons of pure MoS_2.

5. Vatterfjord pr. Solvaer has probably also produced 10 metric tons of pure MoS_2.

[1] *Eng. Min. Jour.*, Nov. 13, 1920.
[2] *Chem. Eng. Min. Rev.*, Sept. 5, 1920.

6. Haugholmen, in Telemarken, has produced 15 metric tons of pure MoS_2.

Of the new mines which have produced the most important are: Ornehommen mine, total production about 15 metric tons of MoS_2; Knaben mine No. 2, total production about 25 tons; Gursli mine, total production about 45 tons; Undalen mine, total production about 32 tons; Syversvolden mine, total production about 3 tons; Lier Molybden A/S, total production about 4 tons.

This gives a total production of molybdenite in Norway up to date of about 800 tons of pure MoS_2. These are the most important molybdenum mines now in operation.[1]

Norwegian molybdenum properties did not operate in 1920.

United States.—So far as the United States Geological Survey has been able to ascertain, there was only one producer of molybdenum in 1920, the Molybdenum Corporation of America, at Questa, N. Mex.

MOLYBDENUM IN ORE AND CONCENTRATES PRODUCED AND SOLD IN THE UNITED STATES(a)

Year.	Quantity Sold (Pounds).	Value.	Year.	Quantity Sold (Pounds).	Value.
1914	1,297	$1,297	1918	861,637	$1,253,700
1915	181,769	114,866	1919	(b)	(b)
1916	206,740	205,000	1920	(b)	(b)
1917	350,200	495,350			

(a) U. S. Geol. Surv.
(b) Not at liberty to publish figures.

During 1920, 15,639 lb. of molybdenum ore, valued at $9707, was imported into the United States, against 106,743 lb., valued at $77,572, in 1919. No record of imports of molybdenum ores was kept by the Bureau of Foreign and Domestic Commerce before July 1, 1918. During the last six months of 1918, 140,222 lb. of ore, valued at $123,924, was imported. It is known that in the first half of the year 25,000 lb. of molybdenite averaging about 75 per cent. of MoS_2 was imported from Chosen and 19,000 lb. from some undesignated part of Asia.[2]

The major part of the molybdenum mined in the United States previous to 1915 was extracted from the wulfenite ore of Arizona. The wulfenite is associated with other complex ores and copper minerals. Where the average run of mine is about 2 per cent. wulfenite (roughly equivalent to 0.9 per cent. molybdenite), mining in loose ground and extraction from complex ores is not a commercial operation at the present price of molybdenum.

[1] *Eng. Min. Jour.*, June 18, 1921.
[2] U. S. Geol. Surv.

In the United States Colorado is now the premier state in production of molybdenite.

ESTIMATED WORLD'S PRODUCTION OF MOLYBDENUM (a)
(In metric tons, Mo content)

	1916.	1917.	1918.	1919.	1920.
Australia, New South Wales	29	36	48	32	.....
Australia, Queensland	44	57	56	62	15
Australia, Victoria	.....	.....	3	43	23
Canada	42	89	102	22	.....
Japan	18	12	.....	.....	.....
Korea	3	60	11	.....	.....
Mexico	.....	.....	14	1	1
Norway	57	90	74	.....	.....
Peru	3	4	2	2	.....
Spain	26	.....	.....	.....	.....
Sweden	.....	22	25	.....	.....
United States	93	159	391	.....	.....

(a) Figures are stated in molybdenum content of ores or concentrates, calculated from official reports. Where given calculation is based on average Mo content as stated in these reports; when not given it has been necessary to estimate the Mo content. Some estimates are taken from the Canadian Dept. of Mines.

MONAZITE

By Sydney J. Johnstone

In company with many others the monazite industry suffered from serious depression during 1920 both as regards the raw materials and manufactured products made therefrom.

The heavy demands made on producers during the war led to an output greater than could be normally utilized under peace conditions. At the present time, there appears to be considerable risk of over-production, and it seems probable that some agreement will be reached between the more important of the monazite-producing companies to ensure that each has a fair share of the available trade.

United States.—Practically, all the monazite used in the United States during 1920 was obtained either from Travancore (southern India) or from Brazil. So far as can be ascertained no appreciable quantity was recovered from domestic sources.

MONAZITE PRODUCTION IN THE UNITED STATES

Year.	United States. (a)			North Carolina.		
	Pounds.	Value.	Per Pound.	Pounds.	Value.	Per Pound
1908	422,646	$50,718	$0.120	(c)310,196	$37,224	0.120
1909	541,931	65,032	0.120	(c)391,068	46,928	0.120
1910	99,301	12,006	0.121	(b) 83,454	10,104	0.121
1911	3,561	427	0.120	400	48	0.120
1912	1,272	159	0.120	*Nil.*	.....	.....
1913	*Nil.*	.....	.....	*Nil.*	.....	.....
1914	*Nil.*	.....	.....	*Nil.*	.....	.....
1915	36,000	3,600	0.100	36,000	3,600	0.100
1916	37,872	3,400	0.090	37,872	3,400	0.090
1917	77,743	3,806	0.049	77,743	3,806	0.049
1918	*Nil.*	.....	.....	*Nil.*	.....	.....
1919	(d)	.....	.....	.....	.....	.....
1920	.....	.....	.....	.....	.....	.....

(a) Statistics are those of the U. S. Geological Survey. (b) Statistics for 1910 furnished by Joseph Hyde Pratt, State Geologist. (c) Statistics for 1907, 1908, and 1909 were collected jointly by the U. S. Geological Survey and the N. C. Geological and Economic Survey.
(d) Only one producer; figures cannot be revealed.

IMPORTS OF MONAZITE SAND AND THORITE (a)
(In Pounds)

From.	1914.	1915.	1916.	1917.	1918.	1919.	1920.
Brazil	1,102,300	1,464,963	352,780	1,079,427	1,122,998	832,022	.....
England	.....	291,342	1,170,721	1,134,433	1,341,571	.....	.....
Canada	.....	2,500	.....	2,340	1,786,050	.....	.....
British India	.....	.....	.....	.....	725,356	774,646	.....
Total	1,102,300	1,758,850	1,523,501	2,216,200	4,975,975	1,606,668	2,810,096

(a) Figures for 1914 to 1918 are for the fiscal years ending June 30, those for 1919 and 1920 are for the new fiscal year ending Dec. 31.

At the present price of monazite sand it seems unlikely that the deposits so far discovered in the United States, can be worked at a profit even when the import duty of 25 per cent. *ad valorem* is taken into consideration.

IMPORTS OF THORIUM NITRATE, THORIUM OXIDE AND MONAZITE (a)

	Year.	Pounds.	Value.	Per Pound.
Thorium nitrate entered for consumption	1912	117,485	$225,386	$1.92
	1913	112,105	212,263	1.89
	1914	101,927	239,376	2.35
	1915	67,406	169,617	2.52
	1916	909	3,884	4.27
	1917	1,188	2,359	1.98
	1918	*Nil.*	.....	.....
	1919	3,307	5,250	1.59
	1920	35,640	43,221	1.21
Thorium oxide and other salts entered for consumption	1915	139	349	$2.51
	1916	4,099	9,487	2.36
	1917	11	293	26.64
	1918	28	124	4.43
	1919	*Nil.*	.....	.....
	1920	.....	.....	.....
Monazite sand (and thorite) entered for consumption	1912	556,959	$47,334	$0.085
	1913	1,145,010	94,425	0.082
	1914	770,842	61,595	0.080
	1915	1,873,971	161,456	0.117
	1916	1,221,399	120,077	0.098
	1917	4,598,926	297,898	0.065
	1918	2,994,515	204,661	0.068
	1919	632,568	48,768	0.077
	1920	1,814,182	141,528	0.078

(a) Bureau of Statistics of the Department of Commerce.

The above tables show that the quantity of monazite sand imported for home consumption into the United States during 1920 was nearly three times as great as in 1919, but only three-fifths of that imported during 1918. No Travancore monazite was offered on the open market during the year, but it is understood that there is no bar to this being done should the producers consider it desirable to do so.

The exports of thorium nitrate to the United Kingdom also increased very considerably. (See under *United Kingdom.*)

German thorium nitrate was offered at $3 per lb. early in 1921 as compared with $3.75 asked by United States manufacturers. It seems probable that the import duty on thorium nitrate will be considerably increased in the near future.

It was stated by R. B. Moore (*"Political and Commercial Geology,"* p. 219) that as the two largest companies making thorium nitrate in the United States supplied practically all the thorium-nitrate requirements of England and France, they controlled the thorium industry. Although this was probably correct at a certain period during the war, it is no

longer true, as the English and French thorium-nitrate manufacturers can now more than supply the requirements of their own countries.

According to R. B. Moore (*loc. cit.*) there are three manufacturers of thorium nitrate in the United States: the American Welsbach Co., which uses about 1200 tons of Brazilian monazite per annum; the Lindsay Light Co., which annually treats about 500 tons of Travancore monazite; and the Block Co. of Chicago, which makes only sufficient of the salt for its own requirements, and thus consumes about 50 tons of monazite each year.

The thorium nitrate made in the United States is used almost entirely for the manufacture of incandescent gas mantles. The value of these goods exported, which went chiefly to Canada, India, South America, Australasia, Dutch East Indies and China during 1918, 1919 and 1920, amounted to $252,284, $358,642 and $478,371, respectively.

India.—Travancore, which first exported monazite sand in quantity in 1911, still continues to supply a large proportion of the world's demands from the beach and dune sands occurring between Muttum and Colachel. The deposits are now being worked by two companies, those on the seashore being concentrated by the Travancore Minerals Co., Ltd., while in a certain area on the dunes inland sands are being treated by Hopkin and Williams (Travancore), Ltd., who work in association with Thorium, Ltd., of London.

The first named and older of the two companies is under an agreement with the Durbar of Travancore to export from that State not less than 1200 tons of monazite concentrate per annum, and hence, owing to the decrease in demand during the past two years, stocks of monazite are accumulating at the port of shipment. The crude sands, which contain from 4 to 6 per cent. of monazite, are first partly concentrated by means of buddles and then raised to marketable grade by concentration on dry blowing tables, this treatment giving a product containing 78 to 85 per cent. of pure monazite and from 7.8 to 8.5 per cent. of thoria (ThO_2). An electromagnetic separator is under trial with a view to producing a still higher grade concentrate. The richest patches of monazite on the beach are produced by tidal concentration and hence are renewed during each monsoon. This company produced 1024 long tons of concentrate during 1920 and shipped 810 tons. The price quoted was about £5 per unit of thoria per ton free at mines.

Hopkin and Williams (Travancore), Ltd., work a deposit situated somewhat inland and are, therefore, less favorably situated as regards tidal concentration than is the older company. Their output of high-grade monazite containing 9.5 to 9.6 per cent. of thoria amounted to between 500 and 600 long tons in 1920, but considerable reserves were

held back in view of the unsatisfactory condition of the market. Production from these concessions could be considerably increased should such be warranted by market conditions.

Monazite has been found associated with pitchblende, mica and apatite in semi-crystalline masses in a mica mine near Pichhli, in the Gaya district of Bihar and Orissa. According to G. H. Tipper[1] the material contained about 20 per cent. of monazite and the latter when separated was found to contain 9.95 per cent. of thoria. It is unlikely that it would prove remunerative to work the deposit for monazite.

Monazite has been found in the bed of a stream near the village of Wan Hapal in Mong Kung, one of the Southern Shan States. According to H. C. Jones[2] the monazite occurs as yellowish green grains in considerable quantity in the heavy concentrate obtained, but the quantity of sand available is small.

Ceylon.—As a result of the work of the Ceylon Mineral Survey, which has been carried out in association with the Imperial Institute (London), monazite has been found in many parts of the island, the more important deposits being near Bentota and Kadremalai on the West Coast.

During 1917 the Ceylon Government decided to work the Bentota deposits, and an electromagnetic separator was sent to Ceylon after trials had been carried out with the machine by the Imperial Institute.

The sand is collected from the beach during suitable weather, washed by hand, and then finally concentrated electromagnetically. The concentrating plant was in operation throughout 1920 and about 70 tons of high-grade monazite was exported. The refined monazite as shipped, which is somewhat similar in appearance to that obtained in Travancore, contains from 8 to 9 per cent. of thoria.

Samples of the Bentota crude sand examined at the Imperial Institute were found to contain as much as 47 per cent. of monazite, but the average material now worked contains a smaller percentage.

An interesting account of the Ceylon deposits of monazite and other thorium minerals is given in the *Bulletin of the Imperial Institute*, **14**, 321–369 (1916).

So far as can be ascertained no thorianite or thorite was recovered in Ceylon during the period under review.

Brazil.—For many years the world's demand for monazite sand was met from the beach sands of Espirito Santo and Bahia, but the discovery of the Travancore sand, which contains a considerably larger percentage of thoria and is more cheaply produced, led to a serious decrease in the demand for the Brazilian material. The principal users of Brazilian monazite are the United States and France.

[1] Rec. Geol. Surv. India, **50**, 255 (1919). [2] Rec. Geol. Surv. India, **51**, 156 (1920).

The quantities (in metric tons) and destinations of the monazite sand exported from Brazil during recent years have been as follows:

Destination.	1913.	1914.	1915.	1916.	1917.	1918.	1919.
United Kingdom..	3	...	...	...	...	...	...
France.....	778	...	...	...	...	...	...
Germany.....	256	...	...	...	...	...	...
United States.....	400	600	439	...	...	...	...
Total.....	1,437	600	439	*Nil.*	1,136	499	146

The concentrated sands exported usually contain at least 85 per cent. of monazite and average about 6.3 per cent. of thoria. Export duties are imposed on both crude and concentrated sand, the amount varying with the state from which the material is exported. The Federal Government imposes a duty of ½ per cent. *ad valorem*, while in Rio de Janeiro and in Minas Geraes the duty is equivalent to 5.1 dollars, and in Espirito Santo to 25.6 dollars per metric ton of concentrate.

Federated Malay States.—Monazite containing up to 9 per cent. of thoria occurs in a number of the tin-bearing deposits of Malaya,[1] and although it could be obtained in fair amount at several of the tin-concentrating plants it seems unlikely that there will be any production of marketable material in the near future.

Madagascar.—Monazite and thorite occur in pegmatites, but so far no important quantities have been exported.

Union of South Africa.—Monazite has been found in a number of localities in South Africa, but where the mineral is abundant the percentage of thoria is usually too low to permit of its being worked in competition with the sands of Travancore. A good account of the occurrences is given by W. Versfeld in "The Base Metal Resources of the Union of South Africa."

France.—The manufacture of thorium nitrate in France was started in 1906 by the Société Industrielle et Minière Franco-Brasilienne. At the present time, two important companies are utilizing monazite sand for the manufacture of thorium nitrate and cerium pyrophoric alloy. A large proportion of the thorium nitrate produced is now exported, as the demand for incandescent mantles in France is at present small owing to the fact that northern France has not yet recovered from effects of the war. Cerium earth residues from the manufacture of thorium nitrate are imported from the United States and used in the preparation of pyrophoric alloys.

Italy.—Thorium nitrate is made by one firm in Italy which exports part of its product to the United Kingdom.

[1] *Jour. Soc. Chem. Ind.*, **33**, 56 (1914).

The manufacture of thorium nitrate from waste mantle ash was started in Turin about 10 years ago and its extraction from monazite sand was commenced in 1913. The plant was increased in 1916 to an annual capacity of 25 to 30 metric tons of the nitrate. The output during 1920 was restricted owing to coal shortage and amounted to only 12 metric tons. The monazite sand used is nearly all obtained from Travancore. It is understood that pyrophoric alloy will be made in the near future.

Great Britain.—The monazite now being used in this country comes almost entirely from Travancore, but a small quantity, however, is being imported from Ceylon.

Brazilian monazite was offered during 1920, but so far as can be ascertained no sales resulted.

The monazite sand and thorium nitrate imported into Great Britain during recent years was as follows:

IMPORTS OF MONAZITE SAND INTO GREAT BRITAIN

	1915.	1916.	1917.	1918.	1919.	1920.	
	Value.	Value.	Value.	Value.	Value.	Tons.	Value.
British India ...					£7,304	650	£13,435
Ceylon.....	£12,802	£8,224	£14,773	£8,065	1,850	72	3,250
South America...					.....	...	.....

IMPORTS OF THORIUM NITRATE INTO GREAT BRITAIN

Source.	1919. (a)		1920.	
	Quantity. Pounds.	Value.	Quantity. Pounds.	Value.
Germany.....	.....	.....	32,000	£21,811
France.....	5,040	£5,888	4,032	1,000
Italy.....	224	190	666	625
United States.....	47,570	51,397	112,795	102,550
	52,834	£57,475	149,493	£125,986

(a) For 10 months only (Mar. 1 to Dec. 31).

During 1920 Germany and the United States exported large quantities of thorium nitrate to the United Kingdom, much of which no doubt was not for the purpose of meeting the immediate demands for the material, but in anticipation of a tariff being imposed in the United Kingdom on certain imported manufactured goods as foreshadowed by the "Key Industries" Bill.

The price of thorium nitrate fell to 26s. per kilo during 1920, but it is said at this price the agents of the United States firms refused to sell.

Thorium nitrate is now being made on a large scale in the United Kingdom by three firms and a fourth is about to commence operations.

The incandescent-mantle trade of the United Kingdom is being seriously affected by competition with foreign imported goods, the increase of which is well shown by the following figures.

INCANDESCENT GAS MANTLES IMPORTED INTO GREAT BRITAIN

Source.	1918.	1919.	1920.	
	Value.	Value.	Quantity. Gross.	Value.
Germany	.....	£421	21,359	£51,710
Netherlands	.....	5,955	19,949	41,409
Belgium	.....	2,783	21,663	54,225
France	£323	167	1,370	3,579
Switzerland	.....	2,413	3,962	8,672
Italy	26,492	16,405	8,769	13,817
Austria	.....	.....	559	1,267
United States	.....	131	283	1,663
Other countries	.....	3,496	445	874
Totals	£26,815	£31,771	78,357	£177,216

It seems probable that the exports from certain of the above countries represent material largely of German manufacture. Great Britain exported during 1920 about 51,737 gross of gas mantles valued at £171,147; about 90 per cent. of these were sent to British dominions.

An interesting report of the position of the incandescent-mantle trade of the United Kingdom was issued recently by the Incandescent Mantle Manufacturers' Association of Great Britain. The progress since 1913 is well illustrated by the following figures:

	Output in Million Mantles.	Capital Employed.	Workpeople Employed.
1913	23.7	£440,670	1,843
1920	82.3	1,525,710	3,783

The report also throws some interesting light on the German pre-war prices for export, as the figures given show that the factory prices in Germany (for home consumption) were from 1.5 to 3.2 times those at which the goods were sold c.i.f. London. The price charged in London for the German mantle was, in all cases quoted, considerably lower than the British factory cost without establishment charges.

Norway.—So far as can be ascertained no thorite or monazite was produced during 1920. Neither thorium nitrate nor incandescent mantles are made in Norway.

WORLD'S PRODUCTION OF MONAZITE SAND
(In metric tons)

	Brazil. (a)	United States.	Travancore.	Ceylon.
1909	6,359	242.0	*Nil*	..
1910	5,345	44.3	*Nil*	..
1911	3,627	1.6	819	..
1912	3,344	0.6	1,135	..
1913	1,415	*Nil*	1,234	..
1914	599	*Nil*	1,185	..
1915	439	16.1	1,108	..
1916	*Nil*	16.5	1,292	..
1917	1,136	34.7	1,940	..
1918	499	(b)	2,117	20
1919	146	(b)	2,023	40
1920	.....	(b)	1,600(c)	70

(a) Exports. (b) Less than three producers, no statistics published. (c) Estimated.

TECHNOLOGY

Considerable attention appears to have been given during the past two years to the possibility of cheapening and accelerating the method used in the extraction of thoria from monazite. In this connection, attention may be drawn to those processes which claim to obtain a separation of the thorium from the cerium earths by converting the former into an insoluble phosphate. This results from lengthening the time and increasing the temperature at which the preliminary "breaking" with sulphuric acid is carried out. Examples of this type of process are given by U. S. Patents Nos. 1,322,185, 1,329,747 and 1,323,735 and English Patent No. 28,749 (1919).

Another group of patents utilize the insolubility of thorium fluoride as a means of separation from the fluorides of the cerium earths which are soluble. Examples of this class of process are U. S. Patents Nos. 1,335,157, 1,307,152 and English Patents Nos. 127,555 and 129,624 of 1919.

No new uses likely to consume any large amount of thorium or cerium earths in the near future have been described during the past year, but some progress has been made in the employment of the cerium metals and salts in metallurgy and ceramics.

According to C. Dantsizen[1] the mechanical and insulating properties of porcelain may be improved by replacing part or all of the silica with various refractory mixtures including thoria. The electrical conductivity of insulating ceramic bodies, in which neutral trivalent or tetravalent earth oxides replace silica, is stated by C. K. Harding[2] to be superior to those made with the ordinary porcelain mixtures. In this connection the oxides of thorium, lanthanum, zirconium and didymium are claimed to be particularly suitable.

A useful paper on ferrocerium was read by Alcan Hirsch before the American Electrochemical Society in April, 1920.

[1] U. S. Pat. No. 1,343,040.

[2] U. S. Pat. No. 1,296,076.

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NICKEL

BY THOS. W. GIBSON

Nickel, though widely disseminated throughout the crust of the earth, is found in comparatively few places concentrated into workable bodies of ore. In the islands of the South Pacific, where climatic conditions have for ages permitted the decay of rocks *in situ*, lateritic deposits containing nickel, cobalt, chromium, and other metals are not uncommon; thus, the island colony of New Caledonia was for many years the chief source of the world's supply of nickel when required in small quantities only.

It is somewhat remarkable that James Riley's discovery of the great value of nickel in alloying steel was nearly contemporaneous with the uncovering and development of the nickel mines of Sudbury, in the Province of Ontario, Canada, which now supply at least 80 per cent. of the world's needs in nickel. The story of the identification of nickel in the Sudbury ores, as related by S. J. Ritchie, has in it the flavor of romance. The outcrops, first discovered in 1883, were of chalcopyrite, and were regarded as valuable for copper only. On shipping a quantity of the ore to the Orford Works in New Jersey, unusual difficulties were encountered in its treatment. The recalcitrant element was found to be nickel, and the fact was revealed to the owners that their mines were of nickel rather than of copper; but although nickel was worth much more per pound than copper, the demand was so insignificant in comparison as to produce a feeling of dismay rather than of elation. Riley's fortunate investigations in Glasgow, and the decision of Benjamin Franklin Tracy, then Secretary of the Navy, to clothe the United States' battleships with armor of the new nickel steel, saved the situation, and gave the Sudbury nickel mines their first strong impulse.

The toughness and non-corrodibility imparted to steel by the addition of 3 or 3.5 parts of nickel quickly led to the use of nickel steel for many industrial as well as naval and military uses. Even prior to the war, the demand from the arts and industries had risen to a point exceeding that for the purposes of warfare, whether on sea or land. When the tremendous conflict broke out, the first few months of bewilderment led to a slackening of production at Sudbury, but as the colossal scale on which the war was to rage became more clearly developed, the demand for the twin products of these mines—nickel and copper—became more and

more urgent. New shafts were sunk, new stopes opened, the mines were crowded with men, additional furnaces and converters were installed, and the output rose to the maximum of capacity. In addition, new refining works were erected at Port Colborne, Ont., by the International Nickel Co. of Canada, the principal operating concern.

The consequence of this feverish activity was that when the armistice was signed, Nov. 11, 1918, the mining companies and the governments and contractors of the allied nations, including the United States, were heavily stocked with nickel for which there was no immediate use. The return of the world from the field of war to that of peaceful industry was a task of tremendous difficulty and perplexity, and is one which is by no means yet complete. Nickel was not wanted for armor-plate, or ordnance, or for the casing of bullets, and there was no immediate outlet for it in bridge construction, the manufacture of automobiles, or the many other branches of industry usually needing it in quantity. The process of absorbing these accumulations of nickel has gone on with disappointing slowness, and the result is that nickel mining, smelting, and the whole work of production has been slackened down to the minimum point.

Producing Companies at Sudbury

There are three producing companies in the Sudbury field: the International Nickel Co. of Canada, Ltd., the Mond Nickel Co., Ltd., and the British America Nickel Corporation, Ltd.

International Nickel Co., Ltd.—This company is an amalgamation of the Canadian Copper Co., the Orford Nickel Works, and other subsidiary concerns, and is the largest of the three operating companies. Its smelting works are at Copper Cliff, and its refineries at Bayonne, N. J., and Port Colborne, Ont. It draws its ore at present altogether from the Creighton mine, whose contents are considerably richer in nickel than the average of the Sudbury deposits, running say 4.5 per cent. as compared with 1.5 to 3 per cent. for other properties. The company is said to have blocked out sufficient remaining ore in this mine for eight or nine years' use on a normal scale of production, and an enormous amount of lower-grade ore is being held in reserve in the Frood mine. The smelter at Copper Cliff contains eight blast-furnaces and six Bessemer converters. The peak year during the war was 1918, when the International turned out 74,254 short tons of matte, containing 39,325 tons of nickel and 16,945 tons of copper. In 1920, the output was 44,928 tons of matte, containing 24,943 tons of nickel and 10,905 tons of copper. For the first three months of 1921 production was again on a reduced scale, the matte product being 4355 tons, the nickel contents being 2523 tons and

the copper 1079 tons. Since then the mines and works have been practically closed, a skeleton force of about 200 men only being retained.

Mond Nickel Co., Ltd.—The Mond Nickel Co.'s works are at Coniston, and its refinery at Clydach, near Swansea, Wales. Its principal mine is the Levack, and it operates also the Garson, Kirkwood, Worthington and Frood Extension. The old Victoria mine, at which the company originally established its works, still yields ore especially rich in platinum metals. The maximum output of this company was in 1918, nearly 15,930 tons of matte, containing 6561 tons of nickel and 6538 tons of copper. In 1920 the production was 8256 tons of matte, containing 3110 tons of nickel and 3703 tons of copper. During the first quarter of 1921 the production was still further reduced.

British America Nickel Corporation, Ltd.—The desire of the British Government to have an independent source of nickel supply for war use led to its obtaining control of this company, which has a very large body of ore in the Murray mine, originally owned by the Vivians of Swansea. The ore is of medium grade. Other mines are the Whistle, Elsie and Gertrude. Smelting works have been erected at Nickelton, Ont., and a refinery at Deschenes, Que. In 1920, the production was 4884 tons of matte, containing 2561 tons of nickel and 1413 tons of copper. The production for the first three months of 1921 was on a similar scale, but the mines and works have since been closed down.

Manipulation.—The methods of mining and smelting in use by the companies are essentially similar, though differing in detail. The product is a Bessemer matte, containing about 80 per cent. of nickel and copper combined, the proportions of the metals depending upon the composition of the ores treated. Thus, the mattes of the International company, in 1920, contained 55 per cent. nickel and 25 per cent. copper, while those of the Mond company contained 38 per cent. nickel and 45 per cent. copper. The British America Corporation's matte more nearly resembles that of the International, carrying 52 per cent. nickel and 29 per cent. copper.

In refining the matte, each of the three companies employs a different method. The International uses both at Bayonne and Port Colborne what is known as the Orford process, the oldest of the three methods. It consists of repeated smeltings of the matte with salt-cake, the nickel separating into the "bottoms," and the copper concentrating in the "tops" of the cooled mass. Several treatments are necessary to complete the separation. The "tops" are blown to blister copper, and the "bottoms" roasted and leached until completely changed to nickel oxide. This is then reduced with charcoal in crucibles or reverberatory furnaces to metallic nickel, and cast into ingots or granulated in water as shot.

Part of the matte is made into Monel metal, without separation of the nickel from the copper. This alloy is tough and non-corrodible, and is coming into large use for purposes where these qualities are especially desirable.

The refinery of the Mond company in Wales is the only one of the kind in the world. It employs a method invented by Dr. Ludwig Mond, the founder of the company, which separates the nickel by utilizing the affinity of carbon monoxide for nickel in a finely divided condition. After the matte is ground, roasted and leached with sulphuric acid to remove most of the copper, the residue is reduced at a low heat to a fine powder. This is subjected to the action of carbon monoxide at 50 to 80° C., and nickel carbonyl vapor is formed. The vapor is decomposed by passing it through a tower containing shot nickel heated to about 200° C.; a layer of nickel is formed on the shot, and the carbon monoxide is regenerated and returned to the volatilizing towers. The nickel shot is alternately exposed to and withdrawn from the action of this gas until large enough for use. The Mond product is remarkably pure, containing up to 99.8 or 99.9 per cent. nickel. In the Mond process the copper is recovered as sulphate.

The Hybinette electrolytic method of refining is used by the British America Corporation. The matte is roasted, leached for removal of copper, then melted and cast into anodes, from which the nickel is electrically plated out, the cathodes being remelted, then cast as ingots, or made into shot.

Sudbury Orebodies.—The orebodies of the Sudbury area are found at or near the contact of norite and granite. The norite is in the form of a belt or band completely surrounding an oval-shaped basin of sedimentary rocks of Animikie age. The inner edge of the band is acidic in character, while the outer edge is basic, and it is in the basic edge, or in offshoots into the adjoining rocks, that the deposits are found. These consist of an admixture of pyrrhotite and chalcopyrite, the nickel-bearing mineral itself being pentlandite. The deposits occur as large lenses or masses and are found not only at the contact, but also close to the contact in the adjoining rocks.

A typical analysis of the ore of ordinarily good grade would show it to contain copper 1.2 per cent., nickel 3 per cent., iron 40 per cent., sulphur 30 per cent., and rock matter 25 per cent.

Rare Metals.—In addition to nickel and copper, precious metals are present in about the following proportions: silver 0.2 oz., gold 0.01 oz., platinum 0.01 oz., palladium 0.15 oz. per ton, together with smaller percentages of other metals of the platinum group. Analyses of samples of roasted matte by Ledoux & Co., New York, give the following results as regards the precious and rare metals:

	Sample No. 1, Oz. per Ton.	Sample No. 2, Oz. per Ton.
Silver	1.84	6.155
Gold	0.027	0.256
Platinum	0.1235	0.988
Palladium	0.197	0.984
Iridium	0.046	0.065

Sample No. 1 is from matte which before roasting contained 55.4 per cent. nickel and 23.5 per cent. copper, while sample No. 2 contained 41.1 per cent. nickel and 45.4 per cent. copper. During the years 1915–18, the residues from the Mond company's refining works were estimated to contain the following amounts of platinum metals (in ounces troy):

	1915.	1916.	1917.	1918.
Platinum	3078	3782	4913	4465
Palladium	5474	....	....	....
Iridium and rhodium	973	....	....	....

From these residues Messrs. Johnston, Matthey & Co., Ltd., of London, extracted platinum as follows (in ounces troy): 1916, 3722; 1917, 4719; 1918, 4958. From 19,528 tons of Bessemer matte treated at Bayonne, the International company obtained in 1919 1770 fine oz. of platinum and palladium, and from 10,911 tons refined at Port Colborne, 87.26 oz.

It will thus be seen that the Sudbury mattes contain important quantities of the platinum metals. In the Mond and electrolytic processes of refining, these metals can be recovered almost automatically, and with practically no additional cost, but the bulk of the matte is refined by the Orford process, in which a large proportion of the rare metals passes into the nickel; a part goes also into Monel metal, and both are lost. Only in the electrolytic treatment of part of the Orford product is there any recovery of the rare metals. In 1920 the International had a recovery of 290 oz. of gold, 37,957 oz. of silver, 88.712 oz. of platinum, 173.772 oz. of palladium, and 19.56 oz. of rhodium, ruthenium, osmium, and iridium.

Nickel Deposits Elsewhere

Canada.—Nickel has been found in Ontario outside of the recognized area of Sudbury, as at Alexo, Lake Shebandowan, Net and Cedar lakes, and Munro township. In all of these localities the ore is of the Sudbury type, but the geological associations are with serpentine and not with norite. So far the only deposit that has produced ore in commercial

quantity is the Alexo mine, in the township of Dundonald, near Porcupine. In 1920, 2215.5 tons were shipped to the Mond Nickel Co.'s works at Coniston for treatment. About 50,279 tons in all have been raised from this deposit. Nickel-copper ore in norite has been found in Manitoba a few miles west of the Ontario boundary. There has as yet been no large development.

New Caledonia.—The nickel ores of New Caledonia are residual in character, being formed by the decay of serpentinous rocks in place. Of these, garnierite is a hydrated silicate of nickel and magnesia, and may be described as an alteration product of the serpentine in which the magnesia and iron have been replaced by nickel. When the magnesia is replaced by nickel oxide, the ore is termed "chocolate ore," and the replacement of the iron oxides by nickel oxides gives rise to "green ore." This alteration or replacement does not usually extend more than 25 to 35 ft., so far as workable ore is concerned. In appearance most of the ore resembles a brownish yellow clay, has a specific gravity and hardness of 2.5, and carries from 10 to 25 per cent. of uncombined moisture. The shipping qualities contain about 7 per cent. of nickel. Formerly the ore was shipped in the raw state, mainly to France and Britain, but of late it has been largely converted into matte before leaving New Caledonia. There is no copper in the New Caledonia ore, and no sulphur.

There are three producing nickel companies in New Caledonia. The oldest of the three, with refining plants in Europe, is La Société le Nickel. This company was incorporated in 1880 with a capitalization of 6,250,000 francs; in 1898 the capital was increased to 10,000,000 francs; in 1912 to 15,000,000 francs, and in 1918 to 20,000,000 francs. Another company is Haut Fourneaux de Noumea, with which the firm of Ballande et Fils is associated. A considerable part of the matte made by Haut Fourneaux is exported to the United States, and refined by the United States Nickel Co. at New Brunswick, N. J. In 1916–18 a good deal of ore was shipped from New Caledonia to Japan and refined there.

The table gives the countries to which nickel and nickel matte were exported from New Caledonia for the years 1914–19. The figures represent metric tons.

By-product Nickel

There are sources of nickel which may be termed incidental, or in which the metal is obtained as a by-product. The silver ores of Cobalt, Ontario, contain also nickel, cobalt and arsenic, all three of which are recovered in the refining works. The nickel is principally obtained as oxide, but considerable quantities of the sulphate are also produced, as

well as refined nickel. In 1920 the recoveries from the Cobalt ores were as follows:

Nickel oxide	20,711 lb.
Nickel carbonate	1,000 lb.
Nickel sulphate	158,725 lb.
Nickel metal	203,953 lb.

Particulars of the recovery of "secondary" nickel are given in "Secondary Metals in 1919," a publication of the United States Geological Survey, written by J. P. Dunlop. In the year mentioned there were recovered in the United States, 2447 tons of nickel from non-ferrous scrap, partly as metal, but mostly in alloys and salts. As nickel is used chiefly as an alloy in steel, it is evident that this quantity formed only a small portion of the nickel and alloys recovered and re-used. The secondary nickel reported was nearly all recovered from old nickel anodes, nichrome, nickel silver and Monel metal. Blister copper invariably carries a small proportion of nickel, and in the electrolytic process of refining this is recovered. Nickel from this source, as salts and metallic nickel, added to the nickel obtained at there finery of the Missouri Cobalt Co. at Fredericktown, Mo., from ores containing nickel, lead, copper and cobalt, amounted in 1919 to 511 tons.

Later figures give the corresponding data for 1920, showing 2200 short tons of secondary nickel recovered, of which 270 tons was obtained as metal and 1930 tons in non-ferrous alloys and salts. The nickel produced from ore mined in Missouri and as a by-product from electrolytic refining of copper amounted in 1920 to 349 tons.

Properties of Nickel

Nickel is magnetic, thus resembling its sister metals, cobalt and iron. In color it approaches silver in whiteness and can be highly polished. Its specific gravity varies with treatment from 7.94 to 9.25, and its tensile strength reaches to 36 tons per square inch. It has great physical hardness, and has a melting point of about 1450° C., which is lowered by the presence of impurities. It can be welded to itself, also to iron and steel, and strongly resists the action of acids and alkalies, being almost incorrodible.

Uses

Coins of pure nickel strongly resist abrasion, retaining their handsome appearances. As nickel bronze it is more easily coined but is less satisfactory in actual use. The non-corrosive qualities of nickel are seen to advantage in chemical apparatus and plant, and in marine construction which comes in contact with sea-water, as in condenser tubes. At high temperatures it is used for glow-lamp tubes, sparking plugs and valve

stems. The chief employment of nickel is in nickel steel, fully one-half of the entire production being used in this way. An addition of 3 or 3.5 per cent. of nickel imparts to steel great toughness and a high elastic limit. In large bridges, locomotive and automobile frames, propeller shafts, etc., it reduces weight and increases strength. For rails in damp places, such as tunnels, or on curves, nickel steel can be used to advantage. Nickel and copper, sometimes also with zinc, are alloyed in a great variety of compositions for tableware, either as such or to be electroplated with silver. These forms are known as cupro-nickel, white silver, white metal, etc. For armor-plating warships, for army field-kitchens, gun-barrels, etc. nickel steel has proven its usefulness. Kitchen utensils of pure nickel never wear out, and were popular in continental Europe before the exigencies of war commandeered them for sterner purposes. The use of nickel for plating other metallic articles is well known. It is now possible to roll and forge nickel 99 per cent. pure. The Nickel Alloys Co. at Hyde Park, Penn., now converts nickel into bars, plates, sheets, and other forms, on an extensive scale. It can be rolled down to a thinness of 0.001 in., and nickel-coated steel can be produced by rolling nickel sheets in conjunction with steel billets. By placing the nickel on one or both sides of the sheet, billet or slab, the desired product is obtained.

Nichrome.—Nichrome is an alloy composed of about 80 per cent. nickel, and the remainder mainly chromium. It is melted in an electric furnace and cast in various shapes and in any weight up to 5000 lb. It has been used for some time in the manufacture of resistance coils and elements for heating apparatus and rheostats. For the heat-treatment of metals, such as annealing, tempering, etc., there is a demand for containers or receptacles made of metals or alloys which will maintain their strength and durability at high temperatures. Nichrome answers these requirements. The surface of containers made from this alloy does not oxidize at great heat, except in oxidizing atmospheres, when a thin film of the oxide is formed which is exceedingly strong and durable, resisting the action of alkalies and of acids such as sulphuric and hydrochloric. Dipping baskets of nichrome are used in immersing small heated iron or steel parts in a carbonizing cyanide bath at 1700° F., and are said to be one hundred times as durable as iron or steel wire baskets. The quality possessed by nichrome of withstanding high temperatures makes it suitable for many important industrial purposes.

Coinage.—It is understood that the French mint struck considerably over one hundred million nickel and bronze coins in 1920. The Colombian Government has been authorized to have $1,000,000 in nickel coined and placed in circulation. Chile has accepted a tender for the

DISTRIBUTION OF EXPORTS OF NICKEL FROM NEW CALEDONIA

Year.	France.		England.		Belgium.		Germany.		United States.		Australia.		Japan.		Total.	
	Ore.	Matte.	Ore.	Matte.	Ore.	Matte.	Ore.	Matte.	Ore.	Matte.	Ore.	Matte.	Ore	Matte.	Ore.	Matte.
1914	23,380	....	44,426	2,494	16,346	2,457	7,906	....	..	305	96	....	.....	....	92,154	5,256
1915	11,935	1,409	36,641	600	.....	.....	.....	....	..	3,519	..	....	.....	....	48,576	5,528
1916	7,806	783	20,129	800	.....	.....	.....	....	..	3,352	..	....	2,743	....	30,678	4,935
1917	2,880	200	15,836	1,170	.....	.....	.....	....	25	4,949	..	....	3,276	....	22,017	6,319
1918	12,259	400	.....	.....	.....	.....	.....	....	..	3,537	..	....	3,352	....	15,611	3,937
1919	1,509	1,000	.....	52	.....	304	.....	....	..	2,508	..	....	.....	....	1,561	3,812
Total	59,769	3,792	117,084	5,064	16,346	2,761	7,906	....	25	18,170	96	....	9,371	....	210,597	29,787

minting in Paris of nickel 5-, 10- and 20-centavo coins. The new money was rendered necessary by the melting down of old coins containing silver. This replacement of silver by nickel in a silver-producing country is worthy of note. Australia is likely to introduce nickel coins in her subsidiary currency.

Canada is about to replace the present silver 5-cent piece, which is inconveniently small in size, with a larger coin of pure nickel. It is understood the Mond Nickel Company will supply the metal. The State Council of Finland has authorized the Bank of Finland and the Director of the Mint to make a contract with a British firm for 20,000,000 coins of nickel bronze, of which 10,000,000 are to be 1-mark pieces, 5,000,000 in 50-penni pieces, and 5,000,000 in 25-penni pieces. In days gone by the mark pieces and the principal fractions would have been minted in silver.

LITERATURE

The Royal Ontario Nickel Commission published a Report in 1917 (King's Printer, Parliament Buildings, Toronto), dealing with the known deposits of nickel in all parts of the world, but especially with those of Ontario. Mining methods, metallurgy and refining, properties and alloys of nickel, recovery of rare metals and sulphur, statistics, and many other topics are fully dealt with, and a bibliography is given covering the manufacture of nickel, and the geology and development of nickel ore deposits. The Report is well illustrated, and there is an appendix giving much interesting evidence on various aspects of the nickel question, which is an important one in the Province, together with a variety of other information.

UNITED STATES IMPORTS AND EXPORTS OF NICKEL

Year.	Imports.						Exports.	
	Nickel Ore and Matte.			Nickel and Nickel Alloys. (a)		Nickel Mnfrs.	Nickel. (b)	
	Long Tons.	Nickel Content, lb.	Value.	Pounds.	Value.	Value.	Pounds.	Value.
1905.	13,451	(c)	$1,626,920	941,966	$331,920	$3,291	9,550,918	$2,894,700
1906.	15,156	(c)	1,816,631	210,000	77,373	8,963	10,620,410	3,493,643
1907.	16,888	18,418,305	2,153,873	180,025	80,994	9,159	8,772,578	2,845,663
1908.	16,322	16,586,423	2,396,217	241,868	91,388	10,010	9,770,248	3,297,988
1909.	18,578	21,916,182	2,927,975	277,911	104,019	4,279	12,048,737	4,101,976
1910.	28,519	32,050,032	4,085,076	323,239	125,013	14,759	15,244,937	4,704,088
1911.	23,993	29,545,967	3,918,556	293,301	104,160	.....	25,099,586	8,283,777
1912.	33,101	42,168,769	5,638,456	223,168	103,300	17,203	25,815,016	8,515,332
1913.	37,623	47,194,101	6,427,639	336,590	133,917	37,200	29,173,088	9,686,794
1914.	29,564	35,006,770	4,956,448	109,213	45,146	13,010	27,595,152	9,455,528
1915.	45,798	56,352,582	7,615,999	32,487	13,687	6,242	26,418,550	10,038,514
1916.	59,741	72,611,492	9,889,122	29,917	7,869	25,880	33,404,011	12,952,493
1917.	61,053	75,510,793	9,612,400	15,964	4,763	45,248	21,996,412	8,940,512
1918.	59,621	73,193,205	11,517,546	10,942	3,229	115,243	17,469,500	6,927,041
1919.	23,057	29,303,228	5,780,380	7,258,070	2,553,354	90,451	3,810,656	1,697,544
1920.	32,650	41,586,108	8,463,872	.....	.....	.....	1,215,232	574,845

(a) Includes metal, nickel oxide, and alloys of any kind in which nickel is the material of chief value, in ingots, bars, and sheets. (b) Comprises domestic nickel, nickel oxide, and matte. (c) Nickel content not stated.

Exports of Nickel from United States, Pounds.	1916.	1917.	1918.	1919.	1920.
To France	2,283,132	1,232,142	2,233,736	1,346,119	72,912
To Italy	2,715,521	5,470,042	5,100,847	525,940	.....
To Netherlands	516,331	.....	.....	57,091	.....
To Russia in Europe	7,767,875	168,000	.....	.....	.....
To United Kingdom	16,674,487	14,409,272	7,803,178	747,437	69,622
To Japan	245,920	275,018	2,063,933	582,946	352,834
To Russia in Asia	1,148,366	.....	.....	.....	.....
To other countries	1,505,247	441,938	267,806	551,123	719,864
Total	33,404,011	21,996,412	17,469,500	3,810,656	1,215,232

CANADIAN PRODUCTION AND EXPORT

(Net Tons)

	1916.	1917.	1918.	1919.	1920.
Ore mined	1,566,333	1,518,783	1,641,617	572,400	981,268
Ore smelted	1,521,689	1,453,661	1,559,892	754,567	937,874
Bessemer matte produced	80,010	78,897	87,184	42,736	57,892
Copper content of matte	22,430	21,196	23,483	12,099	15,957
Nickel content of matte	41,298	41,887	45,886	22,035	30,459
Spot value of matte	$12,116,333	$12,004,141	.....	.....	.....

	Lb., 1916.	Lb., 1917.	Lb., 1918.	Lb., 1919.	Lb., 1920.
Nickel contained in matte	80,441,700	82,620,400	85,767,700	30,395,400	51,701,000
Refined nickel	.....	.....	1,910,800	10,621,000	8,498,300
Exported to Great Britain	11,136,900	12,400,100	13,007,600	4,617,900	13,399,900
Exported to United States	69,304,800	70,230,300	74,613,800	34,881,500	45,451,000
Exported to other countries	.....	.....	57,100	1,517,000	1,348,400
Total	80,441,700	82,620,400	87,678,500	41,016,400	60,199,300

The United States Bureau of Standards has published, in 1921, a Circular (No. 100) on Nickel, written by Paul D. Merica. Part "A" deals with nickel itself, its sources, metallurgy, uses and applications, statistics, metallography, chemical and physical properties, effect of impurities, and technology; Part "B" treats of alloys of nickel, their composition, properties and uses; and Part "C" consists of appendices, giving definitions of physical terms, lists of United States patents for nickel alloys, and a bibliography. The text is illustrated with photographs, charts and graphs.

Manufactures of nickel were also exported in 1919 to a value of $2,412,287, and in 1920 to a value of $1,875,991.

PETROLEUM AND NATURAL GAS

By David T. Day

The outstanding feature of the world's oil trade during 1920 was the rapid rise of production in Mexico, which resulted in a total product of 163,540,000 bbl. for the year, an increase of 76,467,046 bbl. over the output of 1919. During the opening months of 1921 this increase was still proceeding.

It has long been recognized that crude-oil production in Mexico has only been limited by the means of transporting the oil to foreign countries, especially to the United States. With the increased building of tank steamers, and especially the conversion of other craft into tankers, the facilities for transporting oil were so increased as to enable the United States alone to take 106,097,115 bbl. of crude oil, as compared with 52,736,032 bbl. in 1919.

While this expansion of Mexican oil products was in progress, the stimulus of very high prices in the United States had its inevitable effect on domestic production, so that in all 443,402,000 bbl. was produced, an increase of 17 per cent. over the previous year. Consumption of crude oil also increased in 1920, but not at the great rate of production. In all 549,577,000 bbl. of crude represents the total domestic production plus imports. The United States consumed 531,186,000 bbl. In other words, the stock increased by 10,346,000 bbl., the exports amounting to 8,045,000 bbl. There is no outlook for a decline in production in 1921.

The position was too much for the prices. They tumbled rapidly from a maximum of $6.10 for Pennsylvania grade in 1919 to $3.00 in March, 1921. Depression in prospecting work and serious retrenchment in all producing activities were the prompt results of the low prices. The nature of the petroleum industry is such that much time is required for any great change to show itself in definite results. Last to come will be the desired end—decline in oil produced. The profound disturbance in the industry by the phenomenal drop in prices is well illustrated by the fact that producers, usually loath to seek political aid for the industry, are, many of them, clamoring for a tariff of 35 cts. a bbl. as a protection against the influx of Mexican oil. But another element recognizes the

advantage of saving our domestic supply for the future by bringing in all possible foreign supplies. They recognize also that the experts may be right who allow to the Mexican fields only a very short life. Prominent among the authorities who voice this view is Mr. Ralph Arnold, who has published a very clear and convincing exposition of the Mexican situation, with an estimate of about two years before those fields begin to decline, mainly by the influx of salt water, which has thus far been the fate of all the gushers for which Mexico has become the world wonder.

Not only did the United States and Mexico show an increased production for 1920, but the yield of the whole world increased also, and the condition at the end of the year is favorable for a more than normal growth in all the world's oil fields. It is not probable that the fall in prices will offset this tendency to greater production abroad, for the strong companies behind these movements look far ahead to a greater demand than there is any adequate means of meeting. Nor will low prices in the United States in any degree curtail foreign search for oil.

PRODUCTION OF PETROLEUM IN THE UNITED STATES BY STATES (b)

(In barrels)

	1916.	1917.	1918.	1919(c)	1920(c)
Alaska	(a)	(a)	(a)	.....	.....
California	90,951,936	93,877,549	97,531,997	101,564,000	105,668,000
Colorado	197,235	121,231	143,286	.....	110,000
Illinois	17,714,235	15,776,860	13,365,974	12,436,000	10,772,000
Indiana	769,036	759,432	877,558	.....	932,000
Kansas	8,738,077	36,536,125	45,451,017	29,683,972	38,501,000
Kentucky	1,202,569	3,088,160	4,367,968	9,346,593	8,679,900
Louisiana	15,248,138	11,392,201	16,042,600	14,500,000	35,649,000
Michigan	(a)	(a)	(a)	.....	.....
Missouri	(a)	.....	.....	.....	.....
Montana	44,917	99,399	69,323	.....	336,000
New York	874,087	879,685	808,843	.....	906,000
Ohio	7,744,511	7,750,540	7,285,005	.....	7,412,000
Oklahoma	107,071,715	107,507,471	103,347,070	85,000,000	105,725,000
Pennsylvania	7,592,394	7,733,200	7,407,812	.....	7,454,000
Tennessee	677	12,196	8,374	.....	12,700
Texas	27,644,605	32,413,287	38,750,031	90,000,000	96,000,000
West Virginia	8,731,184	8,379,285	7,866,628	.....	8,173,000
Wyoming	6,234,137	8,978,680	12,596,287	13,000,000	17,071,000
Undistributed	7,705	10,300	7,943	.....	.....
	300,767,158	335,315,601	355,927,716	377,719,000	443,402,000

(a) Included in "Undistributed."
(b) U. S. Geol. Surv.
(c) Estimated.

United States Production

In the United States the total again broke all previous records. In the increase most of the great fields shared, as is shown in the table below:

PRODUCTION OF PETROLEUM IN THE UNITED STATES, BY FIELDS, IN 1919 AND 1920
(In barrels)

	Preliminary, 1919.		Preliminary, 1920.	
	Quantity.	Value.	Quantity.	Value.
Appalachian	29,232,000	$110,000,000	30,511,000	$165,000,000
Lima-Indiana	3,444,000	8,000,000	3,059,000	11,000,000
Illinois	12,436,000	31,000,000	10,772,000	40,000,000
Mid-Continent:				
Oklahoma-Kansas	115,897,000		144,226,000	
Central and North Texas	67,419,000	447,000,000	70,952,000	837,000,000
North Louisiana	13,575,000		33,896,000	
Gulf Coast	20,568,000	23,000,000	26,801,000	64,000,000
Rocky Mountain	13,584,000	21,000,000	17,517,000	48,000,000
California	101,564,000	135,000,000	105,668,000	195,000,000
Total	377,719,000	$775,000,000	443,402,000	$1,360,000,000

In the following table a summary is given of crude petroleum statistics from 1909 to 1920, showing the disposition of the domestic production and imports, and the average price per barrel of petroleum at the wells:

SUMMARY OF CRUDE PETROLEUM STATISTICS IN THE UNITED STATES (*e*)

Year.	Domestic Production (*a*).		Imports of Mineral Crude Oil. (*b*).		Estimated Consumption (*c*).		Stocks of Domestic Petroleum (*d*).	
	Thousands of Barrels.	Per Cent. of Yearly Increase.	Thousands of Barrels.	Per Cent. of Yearly Increase.	Thousands of Barrels.	Per Cent. of Yearly Increase.	Thousands of Barrels.	Per Cent. of Yearly Increase.
1909	183,171	.....	70	.....	167,089	.....	116,687	.....
1910	209,557	14	557	696	191,483	15	131,030	+12
1911	220,449	5	1,710	207	211,150	10	137,233	+ 5
1912	222,935	1	7,383	332	240,188	14	122,870	−10
1913	248,446	11	17,809	141	261,692	9	122,803	.....
1914	265,763	7	17,247	3	261,293	.....	141,550	+15
1915	281,104	6	18,140	5	273,271	5	163,755	+16
1916	300,767	7	20,570	13	318,599	17	162,397	− 1
1917	335,316	12	30,163	47	377,736	19	146,042	−10
1918	355,928	6	37,736	25	413,078	9	121,727	−17
1919	377,719	6	52,822	40	418,477	1	127,867	+ 5
1920	443,402	17	106,175	101	531,186	27	133,690	+ 5

(*a*) 1909–1918, inclusive: petroleum removed from producing properties plus oil consumed for fuel on the leases.
1919-1920: Preliminary figures. Petroleum removed from producing properties.
(*b*) From records of Bureau of Foreign and Domestic Commerce.
(*c*) Sum of domestic production and net plus decrease of stocks or minus increase of stocks.
(*d*) Held by pipe-line and other marketing companies on Dec. 31 of each year.
(*e*) Prepared by G. B. Richardson, U. S. Geol. Surv.

AVERAGE PRICE PER BARREL AT WELLS

Grade.	1909.	1910.	1911.	1912.	1913.	1914.	1915.	1916.	1917.	1918.	1919.	1920.
Pennsylvania	$1.65	$1.34	$1.30	$1.60	$2.46	$1.89	$1.56	$2.51	$3.25	$3.97	$4.13	$5.96
Oklahoma-Kansas	0.38	0.38	0.47	0.67	0.94	0.76	0.60	1.26	1.81	2.20	2.29	3.41

The following well data for the States east of California were compiled by the U. S. Geological Survey from information supplied by pipeline companies:

PRODUCING OIL WELLS IN THE UNITED STATES OCTOBER 31, 1920

State.	Approximate Number of Producing Oil Wells.	Approximate Production per Well per Day in Barrels.
California[1]	9,490	32.3
Colorado	70	4.1
Illinois	16,800	1.7
Indiana	2,400	1.1
Kansas	15,700	7.4
Kentucky	7,800	3.2
Louisiana:		
Northern	2,560	31.7
Coastal	140	34.6
Total Louisiana	2,700	31.8
New York	14,040	0.2
Ohio:		
Central and Eastern	18,500	0.8
Northwestern	21,100	0.3
Total Ohio	39,600	0.5
Oklahoma	50,700	6.0
Pennsylvania	67,700	0.3
Texas:		
Central and Northern	9,400	22.9
Coastal	1,700	49.7
Total Texas	11,100	27.0
West Virginia	19,500	1.1
Wyoming and Montana	1,000	55.9
Total	258,600	4.98

[1] Reported by the Standard Oil Co. and the Independent Producers' Agency.

The export trade in petroleum has more than regained the position occupied before the war, so that the total for all oils reached 3,100,509,600 American gallons in 1920, as shown by the table which follows:

EXPORTS OF CRUDE OIL AND REFINED PRODUCTS FROM THE UNITED STATES IN GALLONS

Product.	1917.	1918.	1919.	1920.
Crude oil	172,121,195	205,829,030	248,821,453	337,886,081
Illuminating oil	658,156,487	491,109,815	9,155,147	861,891,942
Lubricating oil	280,437,663	257,317,253	4,795,166	410,874,209
Gasoline, naphtha	415,878,844	559,368,855	372,132,597	642,897,428
Residuum, fuel oil, etc	1,124,524,160	1,200,994,793	617,849,304	846,959,940
Total mineral oils	2,651,118,349	2,714,619,746	2,492,754,027	3,100,509,600

Refinery Statistics[1]

A census of the refineries by the United States Bureau of Mines shows that on Jan. 1, 1921, 415 plants were completed, with a daily capacity of 1,888,80. bbl., while there were only 328 refineries operating, with a daily capacity of 1,714,395 bbl. of crude oil. The United States Geological Survey reports the estimated production of crude oil in the United States for 1920 as 443,402,000 bbl., this being a daily average of 1,211,481

[1] Compiled by H. F. Mason, Petroleum Economist of the Bureau of Mines.

bbl. It is interesting to note that the daily average refinery capacity exceeds the domestic production of petroleum by 677,000 bbl.

During the year 1920 the petroleum refineries of the United States ran 61,136,210 bbl. of Mexican crude oil and 2,513,074 bbl. of Mexican tops through the stills.

The daily average production of gasoline during 1920 was 13,340,291 gal., an increase of approximately 2,500,000 gal. daily over the production of 1919. Exports and shipments of gasoline for 1920 amounted to a daily average of 1,800,000 gal., this being 72 per cent. larger than the daily average for 1919 and an increase of 15 per cent. over 1918. Domestic consumption of gasoline for 1920 exceeded 1919 by 818,000,000 gal., an increase of 24 per cent. Stocks of gasoline at the refineries are approximately 16,000,000 gal. more than those of Dec. 31, 1919.

The daily average production of kerosene for 1920 was 6,339,059 gal., or 76,000 gal. less than the production of 1919. Daily average of exports and shipments of kerosene for 1920 was 328,000 gal. less than those of 1919. Domestic consumption of kerosene was approximately the same as 1919. Stocks of kerosene on Dec. 31, 1920, were about 54,000,000 gal. larger than the stocks of Dec. 31, 1919.

Gas and fuel-oil production for 1920 shows a daily average of 24,211,617 gal., an increase in the daily average of 3,300,000 gal. more than in 1919. Exports and shipments for 1920 were increased 2,000,000 gal. daily over those of 1919. The daily average domestic consumption of gas and fuel oils for 1920 was 1,085,158 gal. more than for 1919. The use of fuel oil for bunkering vessels engaged in foreign trade during 1920 was 88 per cent. larger than the amount used in 1919. Stocks of fuel oil at the end of December were 123,000,000 gal. larger than the stocks at the first of the year.

The daily average production of lubricating oils was 2,859,859 gal., an increase of 540,000 gal. for the year 1920. The daily average of exports and shipments of lubricating oils were increased by 365,691 gal. Domestic consumption of lubricating oils increased 113,026 gal. daily. Stocks of these oils were increased 23,000,000 gal. since the first of the year.

Production by States

Alaska.[1]—Investigations of oil in Alaska were made in 1903 by the United States Geological Survey, which has since then from time to time devoted considerable attention to this subject. The Survey has just published, as Bulletin 719, a report entitled "Petroleum in Alaska," by George C. Martin.

All the oil lands in Alaska were withdrawn from entry in 1910, and

[1] U. S. Geol. Surv. *Press Bull.*

patent has been granted to only one claim, which is in the Katalla field, where a few productive oil wells have been drilled. In spite of the small developments, however, Alaska has produced about 56,000 bbl. of petroleum, all of it taken from the Katalla field. This oil has been consumed locally, most of it by a small refinery near Katalla.

The passage of the oil and gas leasing act of Feb. 25, 1920, started small stampedes to all accessible places where oil seepages were known and led to the staking of many claims, some of them in areas where no indications of oil have been found. Up to September, 1920, the Juneau land office had received 178 applications for oil-leasing permits, covering in all 388,673 acres of land, which by no means includes all the land staked, most of which will no doubt be found worthless as oil land. Systematic drilling for oil will probably be begun in Alaska this year, and oil fields will no doubt be developed in Alaska.

Arkansas.—The development of oil in southern Arkansas, which began in 1919, became great in 1920. Following the drilling of the "Constantine Number One," a great gas well which sprayed much water and a little oil, many wells were drilled haphazard over several counties, but activity centered near the gas well. Several disappointments did little to curb the interest of the wildcatters. Some very intelligent

TOTAL PRODUCTION OF

Year.	Kern River.	McKittrick.	Midway.	Sunset.	Coalinga.	Santa Maria-Lompoc.
Prior	.....	.....	.....	.....	.....	.....
1890	.....	.....	.....	.....	*	.....
91	.....	.....	.....	*	.....	.....
92	.....	*	.....	.....	.....	.....
93	.....	.....	.....	.....	.....	.....
94	.....	.....	.....	.....	.....	.....
95	.....	.....	.....	.....	.....	.....
96	.....	.....	.....	.....	14,119	.....
97	.....	.....	.....	.....	70,140	.....
98	.....	10,000	.....	.....	154,000	.....
99	*	15,000	.....	.....	439,372	.....
1900	826,775	80,000	*	12,500	547,960	.....
01	3,278,840	430,450	4,235	188,600	525,433	*
02	8,988,046	619,296	3,048	167,558	571,233	86,888
03	16,342,099	1,353,206	27,305	352,565	2,138,058	204,890
04	17,226,240	1,856,225	910	390,425	5,097,853	700,450
05	15,253,845	1,373,030	18,530	419,212	8,882,125	3,402,800
06	12,825,166	680,756	11,800	307,550	8,401,105	4,799,411
07	12,346,014	2,415,840	149,944	704,805	8,996,268	8,249,236
08	13,803,579	3,076,300	434,578	1,463,520	10,725,795	8,699,350
09	14,508,242	5,807,360	2,234,455	1,999,701	15,406,619	8,017,455
1910	14,776,345	5,471,613	11,174,207	9,218,904	18,646,570	7,607,830
11	14,078,890	5,477,532	21,584,602	5,559,069	18,311,251	7,465,074
12	12,446,445	5,094,465	25,948,980	5,590,824	19,546,122	6,801,966
13	9,980,940	4,496,842	33,040,129	5,984,651	18,604,626	5,817,711
14	7,930,545	3,820,857	37,479,228	12,546,615	15,925,887	4,303,080
15	8,034,974	3,552,801	33,311,486	6,006,607	13,548,159	4,536,840
16	8,402,525	3,230,644	32,156,818	6,768,658	14,381,493	4,422,410
17	8,495,610	3,252,544	29,487,812	7,072,333	15,938,543	5,789,070
18	7,921,515	3,050,627	27,439,993	6,608,940	16,283,066	7,143,750
19	7,563,025	2,810,848	26,414,067	5,589,885	16,385,610	6,030,910
1920	7,456,515	2,607,240	32,493,229	5,423,781	15,464,198	5,928,060
Total	221,586,265	60,583,476	313,415,356	82,376,693	245,005,605	100,023,481

* Indicates first well.

geological work also failed to produce more successful drilling, for the overlying surface formations gave only vague clues to structure.

By the close of 1920 many producing wells had been drilled, most of them near Eldorado. There a refinery promptly began. Loading racks were built to aid shipping facilities, but until the advent of the three pipe lines to connect the field with Louisiana the outlet will be insufficient, and the price of the oil has now declined to the discouraging level of 40 cts. per bbl. Without doubt the Eldorado field will be a great one. It will also encourage drilling in many other counties of Arkansas, with possibly interesting developments.

California.—The Midway field increased its production by five and a half million barrels in 1920 over its yield in 1919. The Newhall-Ventura field increased by a third of a million barrels. This compensated for slight losses in most of the other fields. The Whittier-Fullerton field held its record of over 28,600,000 bbl. The rate of increase in production was fairly steady for the last half of the year. Another feature of prime importance was the decline in stocks to the lowest level in recent years, to 20,930,000 bbl. from 28,253,000 bbl. at the beginning of the year. The greatest discovery of new territory was the development of the Elks Hills field in the latter part of the year by the Standard Oil Co. This is

CRUDE OIL IN CALIFORNIA

Summerland.	Newhall and Ventura Co.	Los Angeles and Salt Lake.	Whittier-Fullerton.	Lost Hills-Belridge.	Miscellaneous.	Total.
.....	3,283,262	.....	.....	.....	.....	3,283,262
*	307,360	.....	.....	.....	.....	307,360
.....	323,600	.....	.....	.....	.....	323,600
.....	385,049	.....	.....	.....	.....	385,049
.....	470,179	.....	.....	.....	.....	470,179
1,500	524,469	257,109	.....	.....	.....	783,078
16,904	476,490	751,945	.....	.....	.....	1,245,339
39,792	298,866	905,003	.....	.....	.....	1,257,780
130,136	368,282	1,327,011	12,000	.....	4,000	1,911,569
132,217	427,000	1,462,871	60,000	.....	3,000	2,249,088
208,370	496,200	1,409,356	108,077	.....	1,500	2,677,875
183,486	443,000	1,722,887	254,397	.....	248,945	4,319,950
203,616	472,057	2,304,432	302,652	.....	.....	7,710,315
143,552	475,000	2,198,496	1,103,793	.....	.....	14,356,910
131,125	682,185	793,765	2,305,613	.....	3,670	24,334,481
120,506	650,779	1,241,304	2,224,550	.....	39,392	29,548,634
96,871	476,898	2,226,768	2,118,312	.....	29,650	34,298,041
72,810	404,379	2,675,650	2,434,512	.....	10,090	32,623,229
69,060	435,584	3,372,465	3,294,206	.....	69,090	40,102,512
67,862	498,015	5,138,959	4,273,314	.....	125,475	48,306,737
66,338	516,628	4,350,898	5,157,252	.....	126,775	58,191,723
74,725	652,575	3,729,618	6,281,221	4,900	58,970	77,697,568
71,255	661,785	3,223,661	7,081,165	168,410	61,350	83,744,044
65,715	859,885	3,073,427	7,919,779	2,680,961	45,870	90,074,439
62,406	1,022,052	2,898,846	10,657,053	5,274,553	27,375	97,867,184
55,743	968,421	2,504,475	14,130,548	4,830,921	27,375	103,623,695
53,000	1,036,305	2,110,133	13,030,549	4,318,550	27,375	89,566,779
56,775	1,122,033	1,721,453	14,679,672	4,852,431	27,450	91,822,362
56,570	1,186,407	1,501,799	18,155,440	6,295,329	27,375	97,267,832
54,613	1,386,518	1,397,781	24,903,613	5,420,079	27,375	101,637,870
53,680	1,792,465	1,341,415	28,657,683	4,554,821	27,375	101,221,784
54,910	2,122,449	1,311,264	28,694,163	4,139,767	25,610	105,721,186
2,336,537	26,498,949	54,841,532	198,656,785	42,540,722	1,066,053	1,348,931,454

indicated by the fact that in January, 1920, the Standard Oil Co.'s average daily production of crude oil was 69,158 bbl., while in December this had increased to 105,307 bbl., an increase of about 70 per cent. In southern California, the Standard Oil Co.'s wildcat efforts resulted in the discovery of the Huntington Beach field in Orange County, and there is evidence for believing that this field will prove a large producer. One of the wells finished in this area had an intitial production estimated at 6000 bbl. per day. The casing collapsed in the well shortly after it was brought in, and re-drilling is now in progress. Since the first of the year, 1921, the Standard Oil Co. has completed several wells in the Huntington Beach pool, each with an initial daily production of 500 to 800 bbl. Drilling is also in progress 12 miles northwest of Huntington Beach. The discovery of a new oil horizon at a depth of approximately 4000 ft. on the Kraemer No. 2 property in the Richfield district, southern California, has added materially to the production. The effort to increase the proved oil territory of California by wildcatting has extended even to the northern part of the State in Tahama, Colusa, Yolo, Lake, Humboldt and Solano counties, without, however, any decided discoveries thus far.

The development of refining facilities increased greatly during the year, as did the transportation features, but trade was greatly disorganized by the shipping strike.

The production of oil in California since the beginning of the industry is given by districts in the table. The production figures in the tabulation give the crude oil production of each field for each year since the beginning of the industry in the State. It is a history in figures of California's crude oil production and field development.

Colorado.—The development of the Rangely field in Rio Blanco County, Colorado, by the Richmond Oil Co. kept the total product up to 109,600 bbl.—less than the product of the new producer, Montana. The oil from the Rangely field is high in gasoline, and is distilled in the field for that product and kerosene. The residuum is used as fuel. The old Colorado fields declined.

The Chimney Creek structure in Routt County has been examined by Mr. Charles T. Lupton. He suggests that the productive Rock Creek field in southern Wyoming will be found to extend south into Colorado, and that the oil formations may be found at about 1200 ft. as compared with 2600 ft. in Wyoming.

Shortly after the end of the year drilling was begun at DeBeque by the Inland Oil and Refining Co. under a prospecting permit. The Carter Oil Co., which has an adjoining tract, is associated with the prospecting.

Illinois.—The drilling activity remained almost stationary, although fewer wells were abandoned—99 against 230 in 1919. Most of the new wells were drilled in Crawford County.

Early in 1921 oil was accidentally obtained at 40 ft. in a well drilled for water by J. J. Konigsmacher, at Waterloo, Monroe County, south of East St. Louis. The pool is very shallow and spotted. Thirty wells have been drilled, many of them productive; two yielded 125 bbl. a day.

Indiana.—Drilling was chiefly limited to Pike, Gibson and Jay counties, without especially favorable results. The abandoned wells aggregated 97 in 1920, against only 62 in 1919.

Kansas.—The Eldorado, Augusta and Towanda pools, in Butler County, have been the centers of interest since 1916. In 1920 they took second place to Marion County in regard to prospecting activity. According to the *Oil and Gas Journal*, Marion County completed 292 wells, with 90 dry holes and 5 gas wells. The initial production from the above was 76,463 bbl. Butler County completed 574 wells, with 103 dry holes and 2 gas wells, but the total initial production was less than for a smaller number of completions in Marion County. Montgomery and Chautauqua counties and eastern counties were also very active, especially in the Moran district of Allen County. The State produced 38,501,000 bbl. in 1920, a notable increase from 29,683,972 in 1919. In the statistical tables Kansas is grouped with Oklahoma.

The United States Geological Survey has just published a map of the oil and gas fields of Kansas. This map, which is on a scale of 12 miles to the inch, shows not only economic data of special interest to the oil man, but the township and county boundaries, railroads, drainage lines and principal towns and cities. The oil fields are outlined in green and the gas fields in red; scattered occurrences of oil or of gas that are not of sufficient importance to be classified as fields are plainly indicated; the pipe lines are shown in a distinctive color; the locations of refineries are indicated, and the names of the principal fields are given.

This map, which should be of extraordinary value to producers, refiners, and geologists interested in the Kansas fields, was compiled under the direction of G. B. Richardson, of the United States Geological Survey, and was made possible by the co-operation of many of the producing companies and geologists whose interests lie in Kansas.

Kentucky.—The year 1920 was the banner period for the development of shallow wells near the outcrop of Chattanooga Black Shale, in Allen, Warren, and Barren counties. Frequently the oil is obtained just below the Black Shale, often at as shallow a depth as 500 ft., and many small but profitable producers have been obtained above the shale, at 300 to 500 ft. Altogether the number of wells and the initial daily production

declined from 1919. The total product aggregated 8,000,000 bbl. The field was one of the first to be seriously curtailed by low prices in 1921.

Louisiana.—The total for the State aggregated 33,609,000 bbl., a very large increase, about double the output of 1919. The Homer field continued a good producer, and the new Haynes field was brought in just after the close of the year, and promises to add materially to the production. The Bull Bayou field in DeSoto and Red River parishes completed 279 producing wells, but the production was much less than the expectations. The Caddo field was drilled vigorously in all the old neglected spots; the most interesting result was the discovery of a new sand in the Pine Island region, which yielded high-gravity oil (43° B.) at a depth of 2875 ft.

A new map of the oil and gas fields of Louisiana has just been published by the U. S. Geological Survey. It is on a scale of 12 miles to the inch.

Missouri.—There are now 160 wells in the shallow field in Vernon County. The oil is found at 200 ft., and the wells produce from 3 to 5 bbl. a day. Wildcatting is also in progress in Howell, Polk and Webster counties.

Montana.—Late in 1919 Frank Frantz and Charles T. Lupton, formerly of the U. S. Geological Survey, drilled a small well in what became known as the Cat Creek pool, in Fergus and Garfield counties, in central Montana. After several successive failures, they obtained a well showing 350 bbl., early in 1920. Later the flow of the well increased to 2000 bbl. per day from a total of 10 wells. A pipeline was laid to Winnett, the nearest railroad station, whence the oil was shipped to the Wyoming refineries. The oil is high grade, showing about 50 per cent. of gasoline. The many localities in the State will now be prospected where the U. S. Geological Survey has pointed out oil possibilities.

The problem of successfully developing oil in Montana has been materially aided by the investigations of Mr. Frank Reeves, the preliminary results of which have been published by the U. S. Geological Survey, and of Messrs. C. E. Dobbin and W. T. Thom, Jr., who have described oil possibilities in southeast Montana.

New Mexico.—The probable oil resources of New Mexico have been ably discussed by John F. Knox.[1] Mr. Knox shows promising similarity between the conditions in the San Juan basin in New Mexico and certain oil fields of Wyoming.

New York.—The energetic drilling campaign of Pennsylvania and West Virginia was less noticeable in New York, and yet the total pro-

[1] *Eng. Min. Jour.*, July 10, 1920.

duction is stated at 900,000 bbl. The rate of production by months showed a slight but irregular increase during the year.

North Dakota.—Examinations by A. G. Leonard for the North Dakota Geological Survey have shown the possibility of finding oil in the Dakota sandstone where structures are favorable. Mr. Leonard's report also describes the occurrence and utilization of natural gas in North Dakota.

Ohio.—Ohio produced 7,344,000 bbl. in 1920, at a fairly even rate, the deep-sand prospecting sufficing to offset the decline in other pools. In the Lima field about 5000 bbl. of new production was obtained in the counties Wood, Hannock and Van Wert, from 300 new wells. This was a great increase over the drilling in 1919. In all 382 wells were abandoned, which is less than the record for 1919.

Oklahoma.—Again Oklahoma increased the production of oil in a sensational way. The total output rose from 85,000,000 to 105,725,000 bbl. In only one year, 1915, did the State yield a greater output. The year was characterized by the development of many new pools.

Osage County was the greatest factor in new production. Among the new pools opened in this county, that north of Burbank was opened near the middle of the year. It yielded its oil from a depth of 2600 ft. Another pool, in Township 23, R. 7, yielded oil from four sands, at 1700, 2400, 2500 and 2800 ft. In Township 23, R. 9, and Township 23, R. 11, good pools were also developed. Creek County, in which the great Glenn and Cushing pools were developed, gave four times as great initial production for the new wells of 1920 compared with 1919. This was due to intensive drilling, which extended the Jennings pool to the north, and to the Eastern Bristow. The latter will be greatly developed in 1921. In Okmulgee County the Wilcox sand pools, opened in 1919, proved great producers in 1920, and drilling developed three extensions of them. The Phillipsville pool and the others in the Wilcox sand gave oil of high gravity. The Deane pool, in Okfuskee County, yielded a large amount of oil from two sands, one at 2500 ft., the other below 2600 ft. The deeper is the more productive, and is still increasing in production. In Payne County drilling near Cushing, while varying greatly in results from very expensive work, was interesting in giving production in some cases from a depth of 3600 ft. Drilling was active in Pawnee, Noble, Kay and Grant counties. In Grant County two large gas wells were obtained. Development began in Carter County in the Hewitt district in 1919. In the following year this district, which is east of the old Healdton pool, was actively opened up. Gas sands were found near the surface, and oil at varying depths to 2300 ft. The oil is better in grade than Healdton oil, and brings the regular Mid-continent price. Another great gas field was found in Garvin and Carter counties. Taken

altogether, the outlook is for continued peak production in Oklahoma for the year 1921, even without development of any further new fields.

Pennsylvania.—Stimulated by high prices, well drilling was most active all through the year. The results were not satisfactory, either in wildcat territory or in the re-drilling of old established pools. A well was drilled in Washington Township, in Westmoreland County, southwest Pennsylvania, which made a furore by starting off at 1600 bbl. a day, and yielding $183,000 to its owners in the first two months. It was still producing 200 bbl. a day at the end of the year. Further attempts to develop the region into an oil pool were unsuccessful. The McKeesport gas field declined to practically nothing, according to the usual experience with town-lot booms. The most interesting well of the year was the deep test of the Peoples Natural Gas Co., drilled on the Booth and Flynn property near Ligonier, in Westmoreland County. This well reached a depth of 6822 ft., where a great gas pressure was reached, in an unidentified sand. No oil or gas has ever been found before at so great a depth. The well is yielding 300,000 cu. ft. per day.

Tennessee.—A fair well was obtained in the Black Shale region in Robertson County. In all, 15 wells were drilled in the State, but no effort was made to test the limestones and the black shale in Dickson County. At the end of the year greater attention was being paid to developments in the eastern counties.

Texas.—The total product for the State increased from about 90,000,000 bbl. in 1919 to 96,000,000 bbl. in 1920. The increase was chiefly in the coastal region, which rose from 20,000,000 to 25,048,000 bbl. In spite of great wildcatting in all parts of the State, no important new pools were developed. The increase came chiefly from Stephens County, where production spread in many directions from the great Breckenridge pool. Before the close of the year the production from Stephens County had outstripped that of the great Burkburnett pool, where too close drilling was rapidly depleting the region. Stephens County has not yet reached its peak, although over 16,000,000 bbl. came from that county in 1920, a four-fold increase over 1919. The most vigorous extension of the pool is to the northwest, and over into South Bend, Young County. The Ranger region, in Eastland County, failed to maintain its rate of production, and declined from a daily rate of 50,000 bbl. to 16,000 at the close of the year, although drilling was very active. A great gas field has been developed in the Texas Panhandle.

In the coastal region production was stimulated by high prices to such an extent that 1777 wells were completed, compared with 1236 in 1919. The amount of daily production obtained was almost double that of 1919. The development is well described by the *Oil and Gas Journal* as follows :

The greater part of the increases in the pools came during the last six months of the year, under the stimulus of $3 credit-balance quotations and the cry to speed up production. The last month of 1920 shows a decrease in all directions, due to the reduction in quotations to $2.50 per bbl. and general depression in commercial and industrial lines.

The outstanding features of the year under review were the extension of the West Columbia pool and also the Hull pool, the finding of a deep sand below 4050 ft. in the Goose Creek pool and the opening of a new producing district at Blue Ridge, in Fort Bend County, 15 miles southwest of Houston. Continued drilling around known salt domes at Pierce Junction, Harris County; Stratton Ridge, Brazoria County; Davis Hill and east of the Dayton pool in Liberty County; north of San Diego, Duval County; and the territory known as the Terry district, in Orange County, as well as locations in the parishes of South Louisiana, have failed to bring results. Barber Hill, in Chambers County, is another spot that remains in the semi-pool class where it was in 1919.

The extension of the West Columbia pool to the northwest for nearly a mile came unexpectedly in July, the first well being the Texas Co.'s No. 1 Abrams, which blew in with the drill stem in the hole and started off at a 25,000-bbl. per day gait and kept up that flow for months, being conceded to be one of the best wells ever developed in the Gulf Coast region. It went into the sand at about 2685 ft. It was followed by the Texas Co's No. 49 Hogg, an offset to the south, that started with an initial flow equal to the Abrams and kept producing until December, when it sanded. No. 1 Abrams is still making 2200 bbl. per day. Big wells by the Humble Oil & Refining Co. on the Japhet, in the old south part of the pool at from 3400 to 3600 ft., or from 400 to 600 ft. deeper than the original wells in that part of the pool, demonstrated the wisdom of deeper drilling in that section, which is now being done.

Late in the year the Hull pool was extended about one-half mile to the south by the Humble Oil & Refining Co.'s No. 1 Hooks, that started off at 8000 bbl., and at the close of the year it was flowing 3500 bbl., when 55 days old. It was followed by the same company's No. 7 Guedry. This sand is around 3200 ft., or deeper than in the old part of the pool. Evidences of this sand had been given in previous tests to the west, where a heavy gas pressure caused a number of blowouts and prevented completing tests in a proper manner. The close of 1920 finds a search for deep sands under way on the east and southeast sides of the dome by the Republic Production Co. and the Gulf Production Co.

The high price for the Coastal product resulted in an increase of work in the older pools and a consequent increase in the number of completions and new production. The northwest side of the Humble pool was given a test by the drilling of a number of holes to 3000 ft., but the results apparently do not justify a continuance of this work, which was on both the south and north sides of the San Jacinto River.

The Blue Ridge pool, which had been a semi-producing district since April, 1918, when the Gulf Production Co. got a small well on the east side of the dome, came into the limelight in September, when the same company got a 1200-bbl. well on the same side of the dome and this was followed by the Texas Co.'s No. 1 Robinson, almost a mile to the west, which blew out at 3485 ft. and later started making oil, flowing as high as 8000 bbl. in one day wild. The well sanded. The drill pipe was in the hole when it came in. It was recently cleared and deepened to 3520 ft., and is now pumping 100 bbl. per day.

The Robinson showing resulted in 26 tests starting on that side of the dome, and 11 are drilling on the west side.

During the year the Humble Pipe Line Co. and the Texas Pipe Line Co. both doubled the capacity of their 8-in. lines to the West Columbia pool. They are the only lines into that district. The Humble Pipe Line Co. took over the Texas Co. line into the Goose Creek pool, from Dayton Station, and laid an extension into the Hull pool, thus giving it a line from that pool to Webster tank farm and the refinery of the Humble Oil & Refining Co., at Baytown, near Goose Creek. The Gulf Production Co. laid a 6-in. line from Blue Ridge to Lynchburg, on its mainline station from goose Creek to Beaumont. The Sinclair Pipe Line Co. is now laying an 8-in. line from Damon Mound to its refinery on the Houston ship channel. This is the first line of the Sinclair interests in the Gulf country.

The following table gives the total completions, new production, dry holes, and total gross production during 1920:

SUMMARY OF COMPLETION AND PRODUCTION IN THE GULF FIELD IN 1920

District.	Complete	New Production Barrels.	Dry.	Gross Production Barrels.
Anse La Butte	11	1,925	5	32,887
Blue Ridge	17	7,260	12	131,067
Batson	64	1,462	17	497,738
Barber Hill	11	755	17	.....
Damon Mound	40	20,915	13	897,563
Edgerly	47	15,487	14	441,451
Goose Creek	231	58,310	73	5,424,696
Humble	144	29,464	54	3,388,926
Hull	234	120,300	86	4,326,094
Jennings	23	790	9	211,785
Markham	13	1,290	8	114,657
Spindletop	37	395	16	325,575
Saratoga	108	5,920	21	825,221
Sour Lake	69	3,620	31	2,052,906
Vinton	74	6,695	29	1,337,042
Somerset-Piedras	169	1,722	6	243,305
West Columbia	160	268,170	69	11,384,323
Miscellaneous	311	1,915	257	204,471
Total, 1920	1,763	546,191	707	31,146,203
Total, 1919	1,236	281,366	562	20,500,000
Increase	527	264,825	145	10,646,203

The gross production during 1920 aggregated 31,146,203 bbl., of which 11,384,323 bbl. came from the West Columbia pool and 4,326,696 from the Hull. These figures are the highest in the history of either pool. The Goose Creek pool produced 5,424,696 bbl., ranking second in the region, while the Humble pool takes fourth place with a total of 3,388,926 bbl.

Utah.—Renewed interest has been shown in the San Juan oil field which was discovered several years ago. Drilling has been started by the Ohio Oil Co. and the Carter Oil Co., with the object of making deep tests of the territory.

West Virginia.—Intensive drilling in old fields and in many wildcat localities was generally disappointing. Wetzel, Doddridge, Gilmer, Raleigh, Mason, Braxton, Wyoming, Putnam and Ritchie counties were quite thoroughly exploited. The Weir sand development in the Big Sandy district of Kanawha County proved worth while and work there is still being pushed after the decline in prices. The Berea Grit develop-

ment in the Reedy district of Roane County became interesting and is still in progress.

Wyoming.—The total production of oil increased to 17,201,030 bbl., including that used in the fields as fuel. The old Salt Creek field produced almost two-thirds of the total, the rest being scattered over some fourteen major pools which have delivering facilities, either to pipelines or railroads. Additional facilities are required for the development of several other minor fields, in which the drilling has shown interesting quantities of oil. The year was additionally interesting in the fact that the Lance Creek oil field, which rose to prominence so swiftly, has declined from second in importance to fifth place, and the total production is now less than 18,000 bbl. a month, although it was yielding 63,000 bbl. in January, 1920. It is evident that the Rock River field is still capable of considerable extension, and the Lost Soldier and Ferris pools will probably add a great deal of production during 1921. Maverick Springs and Bolton Creek will begin to market their product, and it is altogether probable that the State will again show an increase for the year. The following table shows the production by fields in 1920, with the number of wells completed.

The figures given below are kindly furnished by the *Oil & Gas Journal.* They differ slightly from those furnished by the U. S. Geological Survey.

PETROLEUM PRODUCTION OF WYOMING BY FIELDS IN 1920
(In barrels)

Month.	Salt Creek.	Rock River.	Big Muddy.	Grass Creek.	Elk Basin.	Lance Creek.	Other Fields.
Jan	742,742	53,200	190,800	117,600	52,000	63,500	3,600
Feb	708,255	60,300	178,800	119,400	57,000	48,100	9,900
Mar	768,770	101,500	187,400	125,900	63,700	49,400	15,200
Apr	737,425	109,300	171,600	123,600	62,200	36,100	18,900
May	799,411	82,000	174,000	125,600	66,300	28,000	70,200
June	853,246	72,200	174,000	126,300	66,800	20,300	98,700
July	919,069	102,600	170,900	131,300	70,800	16,500	71,100
Aug	956,366	102,000	168,500	124,200	73,900	15,500	47,400
Sept	989,171	146,600	184,230	121,300	75,200	13,100	57,900
Oct	1,039,945	167,800	179,000	127,400	84,900	16,300	78,258
Nov	843,581	178,100	159,300	119,800	78,400	17,300	32,405
Dec	862,864	180,000	159,000	119,000	77,000	18,300	33,600
Total	10,220,845	1,355,600	2,097,530	1,481,400	828,200	342,100	538,163

WELLS DRILLED BY FIELDS IN WYOMING IN 1920

	Completed.	Production.	Dry.
Big Muddy	23	1,280	5
Salt Creek	24	15,935	2
Lance Creek	29	980	13
Warm Spring etc	45	3,095	5
Big Horn Basin	28	1,575	7
Rock River Medicine Bow	24	11,520	7
Lost Soldier and Carbon Co	27	2,000	13
Fremont County	9	460	2
Miscellaneous	139	4,509	22
Total	248	41,354	76

The refinery activity in the State included the marketing of 340,000,000 gal. of gasoline, 100,000,000 gal. of kerosene, and 14,000,000 gal. of lubricants, and it inaugurated the manufacture of paraffin wax to the extent of over 7000 tons.

PIPE LINES IN WYOMING[1]

Name of Line.	Length, Miles.	Owner.
Salt Creek-Casper (three lines)	50	Midwest Refining Co.
Big Muddy-Casper	18	Illinois Pipeline Co.
Grass Creek-Greybull	70	Illinois Pipeline Co.
Elk Basin-Frannie	17	Illinois Pipeline Co.
Lost Solider-Fort Steele	45	Illinois Pipeline Co.
Mule Creek-Dakoming	12	Illinois Pipeline Co.
Rock Creek-Laramie	42	Illinois Pipeline Co.
Hamilton Dome-Grass Creek	15	Illinois Pipeline Co.
Warm Springs-Thermopolis	7	Singer Securities Co.
Lance Creek-Lusk	25	Illinois Pipeline Co.

[1] *Oil Trade Jour.*, May, 1921.

Foreign Countries

North America

Canada.[1]—Over 90 per cent. of the production of crude petroleum in Canada is still obtained from the old oil fields in southern Ontario, which have now been producing for 59 years. This production has been supplemented during recent years by a small annual production from New Brunswick and Alberta. The total production of crude oil from these fields in 1920 was 196,937 bbl. of 35 imp. gal., having a value of $821,545, as compared with 240,466 bbl. in 1919, valued at $736,324.

A bounty of 1½ cts. per gallon is paid on the marketed production of crude petroleum from oil fields in Canada, the administration of the "Petroleum Bounty Act" being under the Department of Trade and Commerce. According to returns of bounty payments, the production in the province of Ontario was 180,071 bbl., which at the average price per barrel of $4.03 was worth $726,286. The New Brunswick production was 5148 bbl. valued at $19,964, or an average value of $3.88.

During the past 6 years there has been a small production of crude petroleum in Alberta, the recorded production being all from the Turner Valley field, near Black Diamond, about 35 miles south of Calgary. A large portion of the oil production from this source is a very light oil, and on that account not entitled to bounty payment. The approximate production in 1920 was 11,718 bbl. valued at $75,295.

The 1919 production of crude oil included 4225 bbl. valued at $13,141 from New Brunswick; 219,804 bbl. valued at $625,342 from Ontario, and 16,437 bbl. valued at $97,841 from Alberta.

[1] Prelim. Rept. Min. Prod. of Canada, 1920, Can. Dept. of Mines.

The price per barrel of crude oil at Petrolia was quoted at $3.38, from July 19, 1919, to Jan. 12, 1920, when the price was increased to $3.63. On Mar. 1, 1920, the price was again increased by 45 cts. to $3.88, and on Mar. 10 a further increase of 25 cts. went into force, making the price from that date to the end of the year $4.13. The average price for the year based upon monthly settlements was $4.03. The average monthly price in 1919 was $2.87, as against an average of $2.69 in 1918, $2.33 in 1917, $1.98 in 1916 and $1.39 in 1915.

The production, in barrels, in the various fields in the provinces of Ontario, as kindly furnished by the Supervisor of Petroleum Bounties at Petrolia, for 1919 and 1920, was as follows:

Field.	1919, Barrels.	1920, Barrels.
Petrolia and Enniskillen	70,087	65,081
Oil Spring	45,245	39,388
Moore township		7,036
Sarnia township		3,495
Plympton township		531
Bothwell	29,425	26,564
Tilbury E	18,365	623
West Dover		12,171
Raleigh township		489
Dutton	1,272	837
Onondaga	197	341
Moza township	45,860	24,036
Thamesville	801	1,131

Complete returns of the production of oil refineries have not yet been received, but according to inspection returns of the Inland Revenue Department, of the Customs Department, the total quantity of illuminating oils inspected during the calendar year 1920 was 58,940,118 gal., and the quantity of naphtha, or gasoline, and other light oils was 99,826,802 gal., or a total of oils inspected of 158,766,920 gal.

In 1919, ten oil refineries in Canada used 299,986,199 gal. of crude oil, of which 292,281,146 gal. was imported, and 7,705,053 gal. was obtained from Canadian wells. The production of refined oils and petroleum products included gasoline and motor oils, 87,248,413 gal.; "benzoline," "benzene" and other light oils, 4,516,783 gal.; illuminating oils, 55,360,322 gal.; lubricating oils, 16,113,694 gal.; gas and fuel oils and tar, 95,216,183 gal.; wax and candles, 11,271,993 lb. There was also a production of asphalt and other products. The total value of the products of refineries was $42,856,074. According to inspection returns of the Inland Revenue Department, the total quantity of illuminating oils inspected during the calendar year 1919 was 63,480,214 gallons and the quantity of naphtha or gasoline and other light oils was 97,519,950 gallons.

Exports of petroleum entered as crude mineral oil in 1920 were 2,684,427 gal. valued at $293,325, and of refined oil 1,243,335 gal. valued at $205,999. There was also an export of naphtha and gasoline of

WORLD'S MARKETED PRODUCTION OF CRUDE PETROLEUM, 1857–

Year.	Roumania.	U. S. A.	Italy.	Canada.	Russia.	Galicia.	Japan.[1]	Germany.
1857	1,977	.....	.....	.....	.....	.....	.....	.....
1858	3,500	.....	.....	.....	.....	.....	.....	.....
1859	4,349	2,000	.....	.....	.....	.....	.....	.....
1860	8,542	500,000	36	.....	.....	.....	.....	.....
1861	17,279	2,113,009	29	.....	.....	.....	.....	.....
1862	23,198	3,056,690	29	11,755	.....	.....	.....	.....
1863	27,943	2,611,309	58	82,814	40,816	.....	.....	.....
1864	33,013	2,116,109	72	90,000	64,586	.....	.....	.....
1865	39,017	2,497,700	2,265	110,000	66,542	.....	.....	.....
1866	42,534	3,597,700	992	175,000	83,052	.....	.....	.....
1867	50,838	3,347,300	791	190,000	119,917	.....	.....	.....
1868	55,369	3,646,117	367	200,000	88,327	.....	.....	.....
1869	58,533	4,215,000	144	220,000	202,308	.....	.....	.....
1870	83,765	5,260,745	86	250,000	204,618	.....	.....	.....
1871	90,030	5,205,234	273	269,397	165,129	.....	.....	.....
1872	91,251	6,293,194	331	308,100	184,391	.....	.....	.....
1873	104,036	9,893,786	467	365,052	474,379	.....	.....	.....
1874	103,177	10,926,945	604	168,807	583,751	149,837	.....	.....
1875	108,569	8,787,514	813	220,000	697,364	158,522	4,566	.....
1876	111,314	9,132,669	2,891	312,000	1,302,528	164,157	7,708	.....
1877	108,569	13,350,363	2,934	312,000	1,800,720	169,792	9,560	.....
1878	109,300	15,396,868	4,329	312,000	2,400,960	175,420	17,884	.....
1879	110,007	19,914,146	2,891	575,000	2,761,104	214,800	23,457	.....
1880	114,321	26,286,123	2,035	350,000	3,001,200	229,120	25,497	9,310
1881	121,511	27,661,238	1,237	275,000	3,601,441	286,400	16,751	29,219
1882	136,610	30,349,897	1,316	275,000	4,537,815	330,076	15,549	58,025
1883	139,486	23,449,633	1,618	250,000	6,002,401	365,160	20,473	26,708
1884	210,667	24,218,438	2,855	250,000	10,804,577	408,120	27,923	46,161
1885	193,411	21,858,785	.,941	250,000	13,924,596	465,400	29,237	41,360
1886	168,606	28,064,841	1,575	584,061	18,006,407	305,884	37,916	73,864
1887	181,907	28,283,483	1,496	525,655	18,367,781	343,832	28,645	74,284
1888	218,576	27,612,025	1,251	695,203	23,048,787	466,537	37,436	84,782
1889	297,666	35,163,513	1,273	704,690	24,609,407	515,268	52,811	68,217
1890	383,227	45,823,572	2,998	795,030	28,691,218	659,012	51,420	108,296
1891	488,201	54,292,655	8,305	755,298	34,573,181	630,730	52,917	108,929
1892	593,175	50,514,657	18,321	779,753	35,774,504	646,220	68,901	101,404
1893	535,655	48,431,066	19,069	798,406	40,456,519	692,669	106,384	99,390
1894	507,255	49,344,516	20,552	829,104	36,375,428	940,146	171,744	122,564
1895	575,200	52,892,276	25,843	726,138	46,140,174	1,452,999	141,310	121,277
1896	543,348	60,960,361	18,149	726,822	47,220,633	2,443,080	197,082	145,061
1897	570,886	60,475,516	13,892	709,857	54,399,568	2,226,368	218,559	165,745
1898	776,238	55,364,233	14,489	758,391	61,609,357	2,376,108	265,389	183,427
1899	1,425,777	57,070,850	16,121	808,570	65,954,968	2,313,047	536,079	192,232
1900	1,628,535	63,620,529	12,102	913,498	75,779,417	2,346,505	866,814	358,297
1901	1,678,320	69,389,194	16,150	756,679	85,168,556	3,251,544	1,110,790	313,630
1902	2,059,935	88,766,916	18,933	530,624	80,540,044	4,142,159	1,193,038	353,674
1903	2,763,117	100,461,337	17,876	486,637	75,591,256	5,234,475	1,209,371	445,818
1904	3,599,026	117,080,960	25,476	552,575	78,536,655	5,947,383	1,419,473	637,431
1905	4,420,987	134,717,580	44,027	634,095	54,960,270	5,765,317	1,472,804	560,963
1906	6,378,184	126,493,936	53,577	569,753	58,897,311	5,467,967	1,710,768	578,610
1907	8,118,207	166,095,335	59,875	788,872	61,850,734	8,455,841	2,001,838	756,631
1908	8,252,157	178,527,355	50,966	527,987	62,186,447	12,612,295	2,070,145	1,009,278
1909	9,327,278	183,170,874	42,388	420,755	65,970,350	14,932,799	1,889,563	1,018,837
1910	9,723,806	209,557,248	50,830	315,895	70,336,574	12,673,688	1,930,661	1,032,522
1911	11,107,450	220,449,391	74,709	291,096	66,183,691	10,519,270	1,658,903	1,017,045
1912	12,976,232	222,935,044	53,778	243,336	68,019,208	8,535,174	1,671,405	1,031,050
1913	13,554,768	248,446,230	47,256	228,080	62,834,356	7,818,130	1,942,062	(a)995,764
1914	12,826,579	265,762,535	39,849	214,805	67,020,522	(a)5,033,350	2,738,378	(a)995,764
1915	12,029,913	281,104,104	43,898	215,462	68,548,062	4,158,899	3,118,564	(a)995,764
1916	10,298,208	300,767,158	50,652	198,123	72,801,110	6,461,706	2,997,178	(a)995,764
1917	(a)3,681,870	335,315,303	50,334	205,332	(a)69,000,000	5,965,447	2,898,654	1,000,000
1918	8,730,235	355,927,716	35,953	304,741	(b)40,456,182	5,591,620	2,449,069	711,260
1919	6,517,748	377,719,000	38,254	220,100	34,284,000	6,255,300	2,120,500	(e)925,420
1920	7,406,318	443,402,000	(a)38,000	(a)196,000	(a)25,000,000	(a)6,000,000	2,213,083	(e)215,340

[1] And Formosa. (a) Estimated. (b) Includes British Borneo.

1920 BY YEARS AND BY COUNTRIES, IN BARRELS OF 42 GAL.

India.	Dutch E. Ind.	Peru.	Mexico.	Trinidad.	Egypt.	All Other. (c)	Total.	Year.
.....	.....	.....	.....	.....	.....	.....	.....	1857
.....	.....	.....	.....	.....	.....	.....	.....	1858
.....	.....	.....	.....	.....	.....	.....	6,349	1859
.....	.....	.....	.....	.....	.....	.....	508,578	1860
.....	.....	.....	.....	.....	.....	.....	2,130,917	1861
.....	.....	.....	.....	.....	.....	.....	3,091,692	1862
.....	.....	.....	.....	.....	.....	.....	2,762,940	1863
.....	.....	.....	.....	.....	.....	.....	2,303,780	1864
.....	.....	.....	.....	.....	.....	.....	3,715,524	1865
.....	.....	.....	.....	.....	.....	.....	3,899,278	1866
.....	.....	.....	.....	.....	.....	.....	3,708,846	1867
.....	.....	.....	.....	.....	.....	.....	3,990,180	1868
.....	.....	.....	.....	.....	.....	.....	4,595,985	1869
.....	.....	.....	.....	.....	.....	.....	5,799,214	1870
.....	.....	.....	.....	.....	.....	.....	5,730,063	1871
.....	.....	.....	.....	.....	.....	.....	6,877,267	1872
.....	.....	.....	.....	.....	.....	.....	10,837,720	1873
.....	.....	.....	.....	.....	.....	.....	11,933,121	1874
.....	.....	.....	.....	.....	.....	.....	9,977,348	1875
.....	.....	.....	.....	.....	.....	.....	11,051,267	1876
.....	.....	.....	.....	.....	.....	.....	15,753,938	1877
.....	.....	.....	.....	.....	.....	.....	18,416,761	1878
.....	.....	.....	.....	.....	.....	.....	23,601,405	1879
.....	.....	.....	.....	.....	.....	.....	30,017,606	1880
.....	.....	.....	.....	.....	.....	.....	31,992,797	1881
.....	.....	.....	.....	.....	.....	.....	35,704,288	1882
.....	.....	.....	.....	.....	.....	.....	30,255,479	1883
.....	.....	.....	.....	.....	.....	.....	35,968,741	1884
.....	.....	.....	.....	.....	.....	.....	36,764,730	1885
.....	.....	.....	.....	.....	.....	.....	47,243,154	1886
.....	.....	.....	.....	.....	.....	.....	47,807,083	1887
.....	.....	.....	.....	.....	.....	.....	52,164,597	1888
94,250	.....	.....	.....	.....	.....	.....	61,507,095	1889
118,065	.....	.....	.....	.....	.....	.....	76,632,838	1890
190,131	.....	.....	.....	.....	.....	.....	91,100,347	1891
242,284	.....	.....	.....	.....	.....	.....	88,739,219	1892
298,969	600,000	.....	.....	.....	.....	.....	92,038,127	1893
327,218	688,170	.....	.....	.....	.....	.....	89,335,697	1894
371,536	1,215,757	.....	.....	.....	.....	.....	103,562,510	1895
429,979	1,427,132	47,536	.....	.....	.....	.....	114,159,183	1896
545,704	2,551,649	70,831	.....	.....	.....	.....	121,948,575	1897
542,110	2,964,035	70,905	.....	.....	.....	.....	124,924,682	1898
940,971	1,795,961	89,166	.....	.....	.....	.....	131,143,742	1899
1,078,264	2,253,355	274,800	.....	.....	.....	(a)	149,132,116	1900
1,430,716	4,013,710	274,800	.....	.....	.....	20,000	167,424,089	1901
1,617,363	2,430,465	286,725	.....	.....	.....	26,000	181,965,876	1902
2,510,259	5,770,056	278,092	.....	.....	.....	36,000	194,804,294	1903
3,385,468	6,508,485	345,834	220,653	.....	.....	40,000	218,299,419	1904
4,137,098	7,849,896	447,880	320,379	.....	.....	30,000	215,361,296	1905
4,015,803	8,180,657	536,294	1,097,264	.....	.....	30,000	214,010,124	1906
4,344,162	9,982,597	756,226	1,717,690	.....	.....	30,000	264,958,008	1907
5,047,038	10,283,357	1,011,180	3,481,610	169	.....	41,000	285,089,984	1908
6,676,517	11,041,852	1,316,118	2,488,742	57,143	.....	38,000	298,373,216	1909
6,137,990	11,030,620	1,330,105	3,332,807	142,857	.....	40,700	327,615,603	1910
6,451,203	12,172,949	1,368,274	14,051,643	285,307	9,150	33,000	345,685,081	1911
7,116,672	10,845,624	1,751,143	16,558,215	436,805	205,905	67,000	352,484,591	1912
7,930,149	11,966,857	2,133,261	25,902,439	503,616	94,635	150,600	384,667,550	1913
6,190,476	(b)12,705,208	1,917,802	21,188,427	643,533	777,038	295,000	399,264,168	1914
6,833,333	(b)12,386,808	2,487,251	32,910,508	(a)750,000	262,208	526,000	426,370,894	1915
7,076,161	(b)13,174,399	2,489,458	39,817,402	928,581	411,000	820,000	459,433,319	1916
6,732,370	(b)12,928,955	2,533,417	55,292,770	1,599,455	1,008,750	8,149,710	506,362,367	1917
6,823,453	(b)13,284,936	2,458,376	63,828,327	2,082,068	2,079,750	10,763,395	515,546,481	1918
8,453,800	(b)15,780,000	2,561,291	87,072,954	2,780,000	1,662,184	12,142,600	558,553,644	1919
(a)8,500,000	(a)16,000,000	2,790,000	163,540,000	1,628,637	1,089,213	16,771,660	694,790,251	1920

(c) Includes Persia, Scotland, Argentina, Venezuela, etc.
(a) Alaskan field production appears under Germany in 1919 and under Other Countries in 1920.

160,433 gal. valued at $59,432, and an export of mineral wax amounting to 7,125,900 lb. valued at $626,799. The exports in 1919 were: Crude oil, 603,748 gal. valued at $40,648; and of refined oil, 2,846,293 gal. valued at $287,170; naphtha and gasoline, 1,566,707 gal. valued at $428,754.

The total value of the imports of petroleum and petroleum products in 1920 was $47,098,332, as against a value of $29,519,196 in 1919, and a value of $30,649,570 in 1918. The total quantity of petroleum oils, crude and refined, imported in 1920 was 491,372,140 gal., as compared with 451,211,270 gal. in 1919.

On Aug. 25 oil was obtained at a depth of 783 ft. in a well drilled by the Imperial Oil Co., on the bank of the Mackenzie River, 45 miles north of Fort Norman. This post is about 1000 miles in a direct line from Edmonton and 1200 miles of river travel are necessary beyond the railroad. The well was promptly capped and shut in, and no test of the capacity of the well has been attempted. The well was located by Dr. T. O. Bosworth, chief geologist of the Imperial Oil Co. He staked the claims in 1914, and made a statement of it to the Institution of Petroleum Technologists. A second well is being drilled on the shore of Great Slave Lake, about 500 miles southeast of Fort Norman.

In spite of the inaccessibility of the region, prospectors are stampeding the region as well as possible during the Arctic winter, and plans are well developed for sea-plane transportation to the new region.

Mexico.—The productive wells in Mexico are stated to be 359 in number. If these were operated to full capacity they could yield according to present measurements 3,000,000 bbl. per day. To what extent one well would drain another is of course merely conjecture, for there is no probability of this high productive rate being drawn upon. Over 90 per cent. of the production is exported, and the limit is simply the capacity of available tank steamers. This has greatly increased during the past year.

The oldest field in Mexico is Ebano, 40 miles west of Tampico. Here the oil is very heavy, asphaltic, and so viscous that it could not be pumped from the wells if it were not warm. It is therefore distilled at Ebano. The lighter portion is sent to Tampico for refining, while the asphaltic portion is used as fuel for the railroad. The production is now very slight. The Panuco field is nearer to Tampico. The oil is similar to the Ebano oil, from 10° to 12° B. The field is noted for its few failures in drilling. The production is important, but, like the nearby Topila field, salt water has made serious inroads on the production.

The Huasteca field is south of Tampico, and includes the great Casiano, Cerro Azul and Potrero del Llano pools. This oil is lighter

than Panuco and averages 19° to 21° B. The Tuxpam field is south of Tuxpam River and of the field mentioned above. The oil is 19° to 22° B. The Furbero field, formerly of some importance, is 40 miles southwest of Tuxpam. Its oil is still lighter. These fields support the Mexican industry. Farther south, in Tabasco, paraffin oil is obtained, and caused the location of a large refinery at Minatitlan many years ago; but the field has never had great development. Prospecting is now active there as in many other localities widely scattered over Mexico. None of these new ventures has as yet given signs of profitable results. The conditions of occurrence of petroleum in Mexico are well described by Mr. E. de Golyer, in a paper read before the Society of Automotive Engineers, in which he states:

> We have been so impressed with the unprecedented size of some of the Mexican gushers, and by their continued production of large quantities of petroleum over long periods of time without any appreciable decline in the amount of production, that we have perhaps overestimated the total amount of petroleum to be accrued from any single pool. The explanation of the great gushers seems to lie in the very great porosity of the rock in which the petroleum occurs. It collects in a network of caves and channels previously dissolved out of a bed of thick limestone. This condition allows the petroleum to move about very freely while still underground. Furthermore, the petroleum generally lies over water under an artesian head, and as a consequence the field pressure is largely hydrostatic rather than gas pressure, which in most fields is the expulsive force causing the oil to flow. Effectively, the results of these conditions are deposits of petroleum which can be exhausted with a single well, whereas a deposit of the same size under different conditions of occurrence would require hundreds if not thousands of wells to exhaust it.

The potential production of oil has been very seriously diminished by the invasion of salt water in several of the most important fields, including the Tepetate, Huasteca, and Casiano. The Potrero del Llano well, the property of the Mexican Eagle Co., after flowing for 8 years and having produced more than 100,000,000 bbl. of oil, began to yield salt water over night, and since December, 1918, it has been considered a loss. In November, 1919, the Casiano No. 7, actually producing 25,000 bbl. daily and owned by the Huasteca Petroleum Co., turned to salt water. The loss of this well caused this company to drop from first to second place in the production of Mexico in 1919. The wells of the Cortez Oil Corporation in Tepetate have been reported as having become a total loss through salt water. Seven of the principal wells of the Chinampa field have either ceased to flow or are yielding only water.

From the Mexican Government's figures of a potential production of 1,592,740 bbl. daily in March, 1919, and of 1,995,223 bbl. daily in November, 1919, it would appear that the menace from salt water had not reached any great proportions, but it must be noted that during this

time of apparent increasing potential production, the various companies had developed and brought in several new wells which more than offset immense losses from salt water. The appearance of salt water in several of the oldest and largest producing fields will probably stimulate the exploration and development of other fields, particularly the known fields farther south.

The loading facilities from the wharf at Tampico are ideal, the steamers being loaded from alongside the storage farms. At Tuxpam, however, most of the ships are loaded about a mile off-shore from flexible pipes connecting with submerged pipelines. Approximately 90 per cent. of the shipments of oil are made from the port of Tampico. During the first four months of 1919 the vessels entering and clearing the port numbered 577, with an aggregate tonnage of 1,561,113. They were registered as follows: American, 536; British, 22; Norwegian, 13; Danish, 5; Cuban, 1.

Although the number of tank ships available for carrying Mexican petroleum has been greatly increased during the past three years, there still remains a lack of ships, and production has had to be curtailed accordingly.

A great surplus of crude petroleum is stored in ground reservoirs awaiting improvement in the transportation facilities. The Mexican Government has prohibited the construction of any more earth dams because of the loss of oil and the danger incurred by their use. The storage tanks existing in Mexico Jan. 1, 1919, had a total capacity of slightly more than 49,000,000 bbl. A considerable number of steel and cement tanks are under construction at the present time.

The Mexican Government in an official publication states that it realizes the great need of refineries in the Republic and recently has endeavored to encourage their establishment by placing at the disposition of the oil companies various concessions and franchises. These franchises deal with such matters as the right of expropriation of the necessary land, the gratuitous granting of abandoned or national land, right of way for pipelines, railroads, highways, etc., through private land, exemption of import duties for machinery and material destined for refineries.

The refining plants in operation at the present time consist of four in Tampico, one in Tuxpam, one in Vera Cruz, and the oldest one of all in Minatitlan. These refineries have a total capacity of approximately 100,000 bbl. daily. Not more than 22 per cent. of the oil exported from Mexico is sent out in the refined state. The future will probably witness establishment of several new plants of large capacity. According to the Mexican press, the Huasteca Petroleum Co. will soon begin the construc-

tion of a 20,000,000-peso refinery at Mexico City, and a pipeline from its wells to the refinery. A concession to build such a pipeline and refinery was granted to this company by President Diaz in 1908. It is proposed to furnish oil to the various industrial centers through which the line will pass. The Mexican Petroleum Co., now absorbed by the Huasteca Co., has announced plans to increase the capacity of its refining plant at Tampico to 75,000 bbl. daily, making it the largest refinery in the world. The Agwi (Atlantic, Gulf and West Indies) Refining Co., a Mexican corporation financed by American capital, has received a concession to build a refinery at Tecomate, Vera Cruz, with a daily capacity of 12,000 bbl. Recently a number of the oil companies have combined for the establishment of a large refinery to be located at Panuco, the machinery for which will cost more than $5,000,000.

Dr. Ralph Arnold, in writing recently on the condition of theMexican oil fields, said in part:

There are many areas not only with strong possibilities, but with strong probbilities of eventually becoming commercially productive which, on account of inaccessibility or poor prospects, will probably amount to little in the near future. The oil occurs in a few pools, all of the important ones, with one exception, occurring on one long, narrow structure. The oil accumulates from vast areas into relatively very small productive areas or pools. It exists in cavernous reservoirs under such conditions of enormous pressure, unrestricted mobility and easy availability, as to enable its entire withdrawal from any of the important pools within a few months, under the intensive development campaign which has raged and is raging at the present time in the Mexican field. Each well draws from the entire pool so that the amount of oil each owner recovers depends entirely on the number of holes he has on his property. One owner, by intensive development, can force all other owners to a similar development, and hence quickly exhaust the pool. Such is the history of the pools in the last four years. The important point to remember, in direct contrast to conditions in the oil fields of the United States, is that the proven Mexican oil reserve is absolutely at the mercy of its exploiters and may all be exhausted in a few months or at most in one or two years at the promised rate of development.

TABLE OF COMPARISONS

	United States.	Mexico.
Proven producing area	4500 sq. mi.	25 sq. mi.
Production, 1920	443,402,000 barrels	185,000,000 barrels
Number of producing wells	258,600	200
Average daily production per well	4.9 barrels	2600 barrels
Proven oil reserve	5 or 6 billion barrels	300 to 400 million barrels

That is to say, Mexico, with 0.6 per cent. of the producing area, occupied by 0.7 per cent. the number of wells of the United States, produces 40 per cent. as much oil as the United States. The individual production of the wells averages 530 times greater in Mexico than in the United States. The proven oil reserve of the United States, according to the writer's estimate, is now 15 times that of Mexico.

"Now let us turn to some concrete figures regarding the immediate future of Mexico: There have been twelve proven important pools, Panuco, Ebano, Topila, Dos Bocas, Tepetate, Juan Casiano, Chinampa Los Naranjos, Zacamixtle, Cerro

Azul, Protero del Llano and Alamo. Of these Dos Bocas, Tepetate, Juan Casiano, Chinampa, and Potrero del Llano are rapidly going to salt water and, with the exception of Panuco, as far as important production is concerned, are, or soon will be, unimportant. Panuco and Ebano, apparently, will continue for many years producing enough oil and a valuable mixture of oil and water to have an important bearing on the productivity of Mexico. This leaves Zacamixtle, a practically virgin pool, and Cerro Azul, a partly exhausted pool, the latter controlled by a single company, to furnish, with Panuco, the bulk of the proven future supply. Of the exhausted pools, the greatest only produced a little over 120,000,000 bbl. Los Naranjos will probably produce a total of over 150,000,000 bbl. These oil pools compared favorably in area with the present producing pools, so that these latter may be assumed to yield no large excess over the maximum so far attained. Extimates of future production are: Zacamixtle, over 125,000,000 bbl; Cerro Azul, 75,000,000 bbl. remaining; Alamo, 25,000,000 bbl. remaining; Los Naranjos and Panuco each, 50,000,000 bbl. remaining. Total 325,000,000 bbl. Last year Mexico produced 185,000,000 bbl., or an average of about 500,000 bbl. per day. Mexico is now producing about 600,000 bbl. per day; approximately two-thirds of this is coming from Los Naranjos, a pool which will probably be extinct by early summer on account of the encroachment of salt water.

If the present rate is maintained throughout the year, 1921 will see about 220,000,000 bbl. of oil brought to the surface in Mexico, or about one-half the probable production of the United States for the year. But Mexico's proven reserve is less than twice this amount, hence, at the present rate of production, the latter part of 1922 will see the end of the proven big fields in Mexico.

There is little wildcatting going on in Mexico now, probably not over 25 strictly wildcat wells now being actively drilled outside the main producing districts. Whether it is 1½ years or 2 years, or even a little longer or a little less before the break comes, it is certain to come. Last year the United States consumed 531,186,000 bbl. or 87,784,000 bbl. more than it produced. And even excluding our exported crude and refined products, amounting to about 70,000,000 bbl., our consumption exceeded our production by over 13,000,000 bbl. Can we call this over-production? When the break in production in Mexico does come, what will be the reaction on the industry in the United States? How are we to meet the insatiable demands which then cannot be met by domestic fields? Where are the foreign fields from which we can draw to compensate for Mexico?

Nicaragua.—Petroleum springs, which produce considerable quantities of oil, have been discovered in the Department of Chontales, on the northeastern shore of Lake Nicaragua.

Panama-Costa Rica.[1]—An area of some promise and one which is now being drilled for oil or gas, lies in that portion of the Caribbean Coastal Plain adjacent to the Panama-Costa Rican boundary line. The most important oil seepage is located in southeastern Costa Rica on Uscari Creek, one-quarter of a mile above its junction with the Amei River and 2½ miles north of the town of Suretka. Oil works its way to the surface along a fault plane in steeply dipping strata. At this location there is an outcrop of bluish-gray sandy shale, 1000 feet or more in thickness, which is believed to be the source of the escaping oil. The amount of

[1] *Oil Trade Jour.*, May, 1920.

seepage is difficult to estimate owing to the soft character of the soil and its somewhat scattered area. However, from careful observations, the quantity was placed at not more than from 4 to 6 quarts per day. The oil is dark green in color with an apparent gravity of about 28°B.

A few scattered seepages of lesser importance than the Uscari seep have been noted at places throughout the Talemanca and Estrella valleys. They are usually associated with, or in close proximity to, fault planes or shattered areas. The amount of seepage is small. Inflammable gas escapes along the Yorkin River near its junction with the Siaxola River and at points three miles above. A few light seepages of oil and gas occur in steeply dipping strata on the Pacific coast of Panama and Costa Rica. Asphalt deposits are reported at Guanacaste, Sardina, Costa Rica.

Late in the summer of 1918, the Sinclair Gulf Corporation started drilling operations on a well located approximately on the center of Columbus Island. Drilling has progressed at intervals, and the well has now reached a depth of about 2000 ft., and is making much gas.

During the summer of 1918, material and supplies were shipped to a location in the Estrella Valley, Costa Rica. Operations were delayed on account of war conditions at that time, but better progress is being made on the drilling work. This well is showing strong indications of gas.

Trinidad.—Production increased from 1,900,088 bbl. in 1919 to 2,085,109 bbl. in 1920. There was little change in the productive area, or in the disposition of the oil, which was described at length in the former report of this series.

Great difficulty was experienced in obtaining drilling machinery last year, but owing to materially improved conditions a number of new oil companies have, during the past few months, been enabled to commence operations.

The following table shows the number of feet drilled and the oil produced as compared with 1919:

	Year Ended Dec. 31, 1919.		Year Ended Dec. 31, 1920.	
	Feet Drilled.	Oil Obtained, Barrels.	Feet Drilled,	Oil Obtained, Barrels.
Crown lands	49,122	1,588,281	53,404	1,759,816
Private lands	18,937	311,807	23,972	325,293
Total	68,059	1,900,088	77,376	2,085,109

At the close of the year 1920, 22 companies were engaged in producing oil, compared with 13 at the end of the year 1919. The number of new

wells drilled was 67, an increase of 14 over the previous year. Large shipments of fuel oil were made to the British Admiralty and constituted the largest part of the oil exported from the colony, most of the lighter products being exported to private firms.

As in previous years, the Trinidad Leaseholds Co. maintained its position as the largest producer, its output being approximately 60 per cent. of the total production of the island. Several of the smaller concerns have made arrangements to dispose of their production to this company. This it should be able to handle when the additions to the refinery are completed.

South America

Argentina.—The annual product has risen to 1,240,000 bbl., chiefly from the Comodoro Rivadavia field. The output of this field in 1914 was 40,689 metric tons, 1915, 75,869 tons, 1916, 120,695 tons, 1917, 168,984 tons, 1918, 182,468 tons. Four companies are producing, the chief one being the Government agency. There is one large refinery and 6 small ones. In February, 1921, well No. 128 began flowing at the unprecedented rate of 20,000 bbl. a day, according to a dispatch to the *N. Y. Times.* This well is in a new section of the Comodoro Rivadavia field.

Bolivia.[1]—Serious interest in petroleum possibilities in Bolivia dates from about the year 1906, when a number of comparatively small claims were acquired and registered. These early claims, however, were obtained as much for the purpose of speculation as for the intention of actually working the properties. In 1912 a Bolivian oil company was formed, and it spent large sums in surveying extensive properties in the Department of Santa Cruz. With a view to securing the capital required for carrying its plans to completion, this company interested English and Dutch investors successively, but without permanent result. Chilean capitalists entered the field in 1916, taking over the interests of the Bolivian company, and remaining the most important element in the situation until the advent of American interests about three years later.

At present two large American companies, two British concerns, and one Chilean interest have holdings in the Bolivian oil fields. Representatives of the different interests are constantly coming and going in connection with the legal and technical preliminaries, and it is expected that within a few months actual drilling operations will begin. The problem of transportation is one of the first confronting concessionaires, and plans are under discussion for building railways and utilizing inland waterways for shipment of the oil to foreign markets.

[1] *Comm. Rept.*, May 26, 1920.

Concessions for many hundreds of thousands of acres of oil lands were acquired by foreign interests, under a law of 1916, requiring the payment of a yearly tax per hectare on the land, and assignment to the Government of 10 per cent. of the gross output of petroleum. The terms of concessions were changed by a law of February 6, 1920, lowering the tax on oil lands, and by another on February 24, 1920, providing that oil concessions on fiscal lands should not extend beyond 66 years. The latter law also raised the Government's share in the gross product of oil, and added the provision that 20 per cent. of the net profits from the working of petroleum deposits on fiscal lands should be paid into the treasury of the department in which the workings were located.

In granting concessions, the Bolivian Government retains the right to expropriate the oil land to such an extent as may be deemed necessary to supply the domestic demand for oil, 20 years after date of the contract. At the termination of 50 to 66 years of working by the concessionaire, such oil lands as may not have been expropriated shall revert to the Bolivian Government. The Government will take over with the oil lands the equipment installed by the concessionaire.

Brazil.[1]—The petroleum resources of Brazil must, in view of the geological and tectonic conditions, be extremely limited, and although there may be latent possibilities in the Amazon basin toward the interior of the continent, the country as a whole is entirely unsuited to oil production save for that of shale oil, which has received a certain amount of attention in the past. In this respect, the bituminous deposits of the Camamu basin in the Province of Bahia have often been described and several attempts have been made to work them on a commercial scale, but so far without a great deal of success; the material is known as "turfa," and it occurs in several areas throughout Brazil, but more particularly along the coastal belt. A long tract of bituminous shale extends from the mouth of the Amazon southward to Porto Alegre, with which this occurrence in the Camamu basin is associated, but it is very impure and of doubtful economic value.

In a recent newspaper article from Rio de Janeiro, the oil resources of Brazil were painted in extremely glowing colors, particularly in connection with shale oil from "valuable deposits in the interior;" these shale deposits were reported to contain a high percentage of volatile matter, and projects on a large scale were being made to develop them. Dr. Alderson, in his book on the "Oil Shale Industry" (1920), mentions the Brazilian shale deposits as having yielded 44.73 gal. of oil and 19.55 gal. of ammonia water to the ton, but states that they have not been worked commercially. With practically no market for the by-products

[1] *Mining Mag.*, April, 1921.

it is very doubtful whether these deposits would ever constitute a business proposition.

Colombia.—Mr. Arthur H. Redfield, of the U. S. Geological Survey, has published in the *Engineering and Mining Journal* a detailed account of the Colombian oil developments from which the following is abstracted:

The oil-bearing formations of Colombia extend over about 34,000 sq. miles, of which only 618 sq. miles are believed to contain oil in commercial quantity, and only 3 sq. miles have been proved by drilling. The region may be divided into two principal districts, the Caribbean and the Pacific. The Caribbean district may be subdivided into the Caribbean fields, the Magdalena-Santander field, and the Tolima field.

Oil is now produced in the Magdalena-Santander field, but it has been found also in the Caribbean field, which, however, has not been commercially developed. The Tolima field and the Pacific district have been explored only.

The petroleum found in Colombia ranges from a heavy asphaltic oil to a light paraffin-base oil of 41° B. (sp. gr. 0.8187).

The first well drilled in Colombia for petroleum was sunk in 1909 at Tubará, six miles from Puerto Colombia. The Atlantic Oil Co., composed of capitalists from Toronto, Canada, after two unsuccessful tests, struck a high-grade paraffin-base oil at a depth between 700 and 800 ft. This well is still producing about a barrel a day, which is refined on the ground for use as automobile fuel. Gas was encountered in large quantities and at high pressure, and is used on the property as fuel. In 1912 the contract rights were transferred to the Three Seas Petroleum Co., of Chicago, which controls under lease about 400,000 acres in the vicinity and which purposes to continue operations.

Soon after work was begun on the Tubará lands a well was drilled at Turbaco, 10 miles from Cartagena, by Diego Martinez & Co., of Cartagena, to a depth of 2000 ft. Showings of oil and gas were obtained, but work was not continued in that vicinity. The oil encountered was reported to be high in naphtha.

The same Diego Martinez, after having "denounced" (claimed) certain claims in the Lorica district, on Sinu River, in 1909 or 1910, contracted with the Standard Oil Co. of New York for their exploitation. This company sent down an outfit and began drilling in 1914. Three wells were drilled, in which showings of oil were encountered, but because of mechanical difficulties no oil was produced commercially, and work was abandoned in 1915. Diego Martinez & Co. are now operating in the region of the Gulf of Urabá.

Mineral oils have not been exploited in Colombia principally for three reasons: (1) Transportation is difficult and has been confined chiefly to the coast and to the immediate basins of the large rivers; (2) the local geology presents peculiar features, which have not all been adequately studied; and (3) certain practical difficulties of operation have not been fully overcome.

Ecuador.—The Ecuador Department of Overseas Trade has just issued a report on the trade and commerce of that country in which references are made to the oil industry.

Throughout the year the various companies have sunk several wells at Santa Elena, Selinas and Manta, with no apparent success, but drilling operations are being continued. A small oil source, probably capable of

producing about 40 bbl. of oil per diem for a short period, was recently encountered by the M. & H. Exploration Co. in the course of their drilling operations at Santa Elena, but this they have closed up and are proceeding to sink deeper.

The Anglo-Ecuadorean Oilfields, Ltd., have drilled a second well to a depth of 3000 ft. without result, and are now contemplating the sinking of a third well on other holdings some 15 miles to the north of the present sites.

The British Controlled Oilfields, Ltd., has been operating continuously without result, as also the International Petroleum Co.; and it has yet to be proved whether oil exists in commercial quantities in Ecuador.

It may be mentioned that there are numerous surface wells operated which have been producing several thousand barrels of oil per annum, sold to a few local industries for fuel. These surface wells continue to be operated with decreasing production.

In 1919 a transitory decree was passed by the Congress reforming the existing mining law of the Republic, as applicable to petroleum only. This transitory law met with considerable opposition on the part of those interested in the oilfields, especially because thereunder the rights of the grantees would lapse *ipso facto* if, at the end of two years, the exploitation of the mines granted was not started; and purchases and transfers of mining lands were thereby suspended. Last Congress, however, passed another law, the principal features of which are the extension of time from two to five years in which to commence scientific exploitation, and, pending the new oil law, the transference of oil rights with the approval of the president of the Republic.

Peru.—Production aggregated 2,790,000 bbl. in 1920, against 2,561,000 in 1919. There was little change in the area of the proven fields. A tax of 25 cts. a metric ton is imposed on the exportation of crude oil and its products.

The oldest and best known area in Peru is that occurring as a coastal belt extending from the Gulf of Guayaquil (Malpelo Point) southwards for about 250 miles to Point Aguja. This tract of country stretches inland to the western slopes of the Cordillera and embraces the well-known fields of Negritos, Lobitos and Zorritos. Its rocks are of Tertiary age, consisting of productive Lower Miocene shales and sands capped by clays, sands and conglomerates of Upper Miocene and Pliocene age.

Of the three fields mentioned above, that of Negritos is probably the most important; it is certainly the oldest known as the ruins of the ancient shallow workings from which the Incas used to collect the oil are still to be seen. The Lobitos field is a later development and comprises an area

in which a number of highly productive wells have been sunk. These fields, together with that of Zorritos, are being rapidly expanded. The port of shipment is Talara, where there is also a large refinery.

Several other areas is this country are petroliferous, and mention may be made of such promising localities as Mito (Province Jauja), La Brey in the Chumpi district (Province of Parinacochas), while a later development near Pusi in the Province of Huancane has shown the occurrence of paraffin oil of high quality. Asphaltic rocks are also widely distributed, especially in the provinces of Luya and Tarma.

Uruguay.—From information published in the *Commerce Reports* by Consul David J. D. Myers, of Montevideo, it is learned that investigations for oil have been carried out in Uruguay by the Instituto de Geologia y Perforaciones, with the result that indications have been found in various parts of the Republic, notably in the northern and northeastern parts where the oil-bearing or bituminous strata of southern Brazil extend into this region. Borings have been made near the city of Melo to a depth of nearly 1640 ft., piercing sedimentary strata of shale and sandstone. At a depth of some 500 ft., flows of water were encountered having a strong odor and taste of petroleum.

Statements have also been made by various investigators, who have made surveys in the southeastern part of the Republic, that oil-bearing strata are likely to be found in that region. Water is said to have a very strong odor of hydrocarbons. Up to the present, however, no detailed information as to the localities has been available. Tests of samples from the northeastern regions of the Republic carried out by the Instituto de Geologia y Perforaciones showed the following results: 60,000 liters of gas per ton of schist; 50 kilos of oil per ton of schist; 100 kilos of ammonia per ton of schist.

Venezuela.—Production in Venezuela has progressed slowly, due to obstacles of many kinds, from political interference to malarial fever. The present condition of the oil fields has been most excellently presented in the *Engineering and Mining Journal*, by Mr. Arthur H. Redfield, of the Foreign Minerals Section of the U. S. Geological Survey. This article has furnished most of the following information.

PRODUCTION, REFINING, AND EXPORTS OF VENEZUELAN OIL, 1917–1919.

	Production, Barrels.	Refined at San Lorenzo, Barrels.	Exports to Curacao, Barrels.	Exports to Other Destinations, Barrels.
1917	119,734	58,185	61,541	6
1918	332,607	161,666	172,489	5,012
1919	423,895	354,000(a)	60,522(a)	(b)

(a) Estimated. (b) No data.

Commercial production began in 1914, when the Caribbean Petroleum Co., of Camden, N. J., began drilling in the Mene Grande field, 70 miles east of Maracaibo, in the Miranda district east of Lake Maracaibo. This location was the result of thorough exploration work under Dr. Ralph Arnold, covering 1028 areas of 1236 acres each. The oil is shipped for treatment partly to the refinery of the Royal Dutch on Curacao Island or to the refinery at San Lorenzo. Within late years various other companies have begun exploratory work.

EUROPE

France.—The only petroleum production in France in 1919 was at Pechelbronn, Department of Basrhin. The gross production was 330,000 bbl. From the crude product 1865 tons of gasoline, 9935 tons of dark lubricating greases, and 5303 tons of other products were obtained. This Alsatian field covers about 100,000 acres. It is remarkable for the fact that considerable exploitation is effected by pits as well as by drilled holes. A recent extension gave a well yielding 300 bbl. a day.

Germany.—A cablegram from Consul General Coffin, who is attached to the American Mission in Berlin, states that private statistics show that the crude oil production of Germany reached 29,950 tons in the year 1920, as compared with 33,000 tons in 1919. No official statistics on petroleum in recent years are available. It is stated that all of this production came from the Hanoverian fields and that two-thirds of the former German production came from Alsace Lorraine.

During the last few months negotiations have been carried on between the leading German petroleum companies and the group of French stockholders in control of the larger petroleum enterprises in Poland and the Austrian succession states.[1] These negotiations resulted in the formation at Zurich, on Mar. 1, of the so-called International Petroleum Union, a trust company capitalized at 210,000,000 Swiss francs, in which the Swiss bank takes a leading interest.

The new company has acquired more than 75 per cent. of the capital stock of the German Crude Oil Co. of Berlin, which latter company only recently raised its capital to 100,000,000 marks, as well as 75 per cent. of the capital of the French Société des Pétroles de Dabrowa, of Paris. The capital of this company is soon to be raised to 150,000,000 French francs. The Société des Pétroles controls the majority stock in the Galician Karpathian Petroleum Co., formerly Bergheim & McGarvey, and in the "Schodnica" Co. for Petroleum Industries, which possesses a number of refineries and similar enterprises in West, Central, and East Galicia. The new Swiss trust company is making considerable invest-

[1] *Eng. Min. Jour.*, Apr. 9, 1921.

ments for the purpose of extending its sphere of influence, especially in transatlantic countries. These steps will be taken chiefly with the object in view of securing a larger percentage of the world's petroleum production for the countries interested in the formation of the International Petroleum Union. Furthermore, the company intends to introduce mining methods to obtain crude oil which proved so successful in the Alsatian and Hanoverian oil districts before and during the war. The production of mineral oil from bituminous shale as well as from bituminous coal, as now practiced in certain parts of the Central German lignite district, will also be taken up by the company. It is said that, chiefly for political reasons, neutral Switzerland was selected as headquarters of the company.

Great Britain.—The Petroleum Department of the British Government reports that in the oil-drilling operations in the United Kingdom during 1920 progress has been satisfactory considering the great depths which most of the wells have reached, the total number of feet drilled being 7670. Drilling operations are in progress in Derbyshire, North Staffordshire, and in Scotland.

It is stated that six wells have reached a depth of 3000 ft. or over, one (Ironville No. 2) being 4006 ft., while three others are approaching that depth.

At Hardstoft the uniform rate is about 1 ton per day, or 50 bbl. per week. Total production since the well was brought in, to Dec. 31, 1920, reached 4575 bbl. In 1920, production was 2909 bbl.

The expenditure in 1920 for oil operations amounted to £126,065.

An interesting report upon the shale deposits underlying the county of of Norfolk, England, has recently been issued.[1] The shale is said to be found at shallow depths and can be delivered at the principal works at a cost of 5s. ($1.21) per ton. The yield of a good quality of crude oil by means of treatment in specially designed retorts is reported to be satisfactory, and the nearness of the deposits to the surface makes possible the removal of the overlay and the excavation of the shale by means of mechanical diggers.

Two commercial seams of shale have already been opened up and are at the present time available for production, though a number of other shale seams have been disclosed beneath these in boring operations to test the full depths of the shale deposits.

The upper seam is a hard, well-laminated body of shale 8 ft. thick, having two small bands of "blaes," or less hard and laminated shale, intercalated with its other members, respectively, 6 in. and 5 in. thick. The whole seam, including these bands, can be classed as rich commercial

[1] *Chem. Met. Eng.*, Dec. 22, 1920.

oil shale. Variations in physical properties and chemical composition naturally occur in a seam of this thickness, and these differences have been carefully noted and analyzed.

The lower seam is 8 ft. thick. Its roof is 37 ft. from the surface and its base rests on a band of pyrites at 45 ft. which forms a good hard floor. This is a good mineable seam, being composed of a black shale 4 ft. thick, and a lower 4-ft. seam of hard, dark-green shale.

The oil content is present in a dual form—namely, in a state of free oil absorbed from some source of liquid oil beneath or in juxtaposition to the beds affected, and, secondly, in the form of a heterogeneous material of unknown origin, indigenous to and probably deposited along with the other elements of the shale at the time of its inception. The yield per dry ton of shale treated is stated to average 33 gal. of oil content, from which may be recovered 7 gal. of gasoline, 9¾ gal. of kerosene, 9 gal. of lubricating oil, with a bituminous residue of 50 lb., equivalent to 5 gal.

Poland.—The London *Petroleum Times* credits Mr. Stanislaw Widomski, Vice-president of the Polish State Oil Department, with the following information:

The output of oil in 1920 amounted to 764,820 tons (4,818,366 bbl.), or an average of 63,740 tons per month, which is a decrease of 5570 tons on that of 1919. This decrease was but temporary, and is explained by the almost complete stoppage of boring activities in Galicia during the war. No well continues to be productive beyond a certain number of years; therefore a systematic organization of the oil industry must provide for the drilling of a certain number of new wells each year. At present extensive drilling operations are being carried out in Galicia, and there are already many productive wells which have been drilled since the war. These are shallow wells (not more than 950 ft. deep), chiefly in West Galicia. In East Galicia the wells are considerably deeper, penetrating as far down as 5250 ft.

Just now the Polish oil industry is meeting with many impediments in its development, which are the effects of the war, and, above all, of the incredibly high prices of material. In spite of this, the Government resolved to carry on boring operations, and in January, 1920, there were 185 wells in course of boring, while in December, 1920, there were 221. The State Oil Department is projecting the creation of a special fund, to be derived from trade in oil products. This fund will be devoted to the crediting of new drilling operations, which would considerably increase the output of oil.

As is well known, large oil zones belong to the State, and by a suitable exploitation of these zones not only will the production of oil be increased, but the present unsatisfactory state of oil possession will come to an end,

to the advantage of Polish capital. In this respect the Government has been of great help in calling into being the Geological Department at Cracow, the work of which has already given important results.

Great improvements may be noticed in the output of the Polish refineries. In the second half of 1919 the output of oil by-products amounted to 236,500 tons (70,653,656 gal.), 36,560 tons of motor spirit (10,921,512 gal.), 49,970 tons (14,927,472 gal.) of fuel products, and 149,970 tons (44,800,392 gal.) of naphtha, paraffin, lubricating oils and gas oil. In 1920 the output of the refineries amounted to 608,220 tons (269,893,051 gal.), 76,900 tons of motor spirit (22,972,236 gal.), 141,770 tons (42,812,826 gal.) of fuel products, and 389,550 tons (1,842,246 gal.) of other products. The improvement is therefore considerable, an increase of about 30 per cent.

Petroleum and its by-products are at present Poland's principal export articles and consequently the principal means of obtaining foreign currency. Oil exports in 1920 constituted one-half of the country's entire export trade. In 1920 Poland exported 199,610 tons (60,282,420 gal.) of oil products, or 58 per cent. more than in the first half of 1919 (63,090 tons or 18,846,824 gal.). In 1920 there was exported nearly two-fifths of the total output, whereas in 1919 scarcely one-quarter was exported. There was, besides, a very favorable change in the nature of the exports themselves. Before the war 66 per cent. of the oil exports from Galicia consisted of crude oil, whereas in 1920 this figure was only 15 per cent. and 85 per cent. consisted of products. The Government is constantly endeavoring to increase the productive capacity of the refineries. In the second half of 1919 the refineries worked up 39,260 tons (11,728,105 gal.) per month, and in 1920 55,730 tons (16,648,170 gal.), or an increase of 40 per cent.

The Polish oil industry, said Mr. Widomski, which is one of the most important sources of national wealth, has a great future before it, all the more so because Polish oil, especially in the Boryslaw Basin, contains a high percentage of paraffin, and is therefore very valuable and much in demand in foreign markets.

When the Polish administration of Eastern Galicia began, there was a rush of foreign capital into the oil fields. Before the war there had been plenty of British (chiefly Canadian), French, Belgian, German, and Dutch capital invested, although, of course, the majority control was in Austrian hands. After the close of the conflict more British, French, and Belgian money was brought in so rapidly that during the past year practically the entire industry has changed hands, refineries as well as oil fields. At present, it is reported, French capital dominates. One of the largest French companies is the Mugeot, which acquired its lands by

direct purchase from the proprietors. There is very little American capital, only one company being recorded.

Roumania.—The Roumanian oilfields are located in the foothills of the Carpathian mountains, in Prahova, Bacau, Buzen and Dambovitza. Nearly all the product comes from Prahova. The crude oil is practically all refined in Roumania, and chiefly serves domestic needs, although formerly a considerable proportion of the refined products was exported. In 1916 the wells and refineries were destroyed before the invasion of the Germans. They promptly repaired the damage as much as possible, and brought the production up to 450,000 metric tons in 1917 and to 1,214,000 tons in 1918.

Consul Edwin C. Kemp, at Bucharest,[1] has lately reviewed the Roumanian conditions, and finds that the low rate of production in 1919 and 1920 was due chiefly to a strike in midsummer of 1919 and to lack of drilling supplies.

The following table gives in detail the output of refined oil and export statistics for 1919 and the first half of 1920:

Output of Refined Oil.	1919.	Jan. 1–June 1, 1920.	Exports.	1919.	Jan. 1–July 15, 1920.
	Metric Tons.	*Metric Tons.*		*Metric Tons.*	*Metric Tons.*
Naphtha	155,072	75,941	Naphtha	2,298	25,155
Refined oil	157,958	74,740	Refined oil	26,281	59,030
Fuel oil	364,702	179,284	Gas oil	5,568	12,653
Gas oil	56,334	26,371	Pitch	1,200	380
Loss	17,396	8,562	Crude oil	3,600	3,500
Total, crude oil	751,462	364,898	Total	38,947	100,718

The decreasing value of the lei and the lack of transportation made it difficult to obtain materials needed for the repair and maintenance of the refineries and wells. This lack of transportation, which included the unrepaired pipelines, also made it difficult to utilize the storage facilities at the ports and necessitated stopping the flow of a number of wells.

The increased importance of petroleum in the economics of the country, due in part to the readjustment of the agrarian interests and the awakened interests of the Roumanians in the industry, has another aspect of more importance to the foreign investor. This is the increasing number of restrictive decrees tending to nationalize the industry, and apparently limited only by the protests of the foreign powers. The most important of these decrees include the suspension of the valability of oil concessions except as approved by the Government, the establishment of

[1] *Comm. Rept.*, Oct. 26, 1920.

high taxes on exportation, and the establishment of a company with State participation for the monopoly of the interior sale and importation of oil products, with the right to use such means of distribution, pipelines, tank-cars, etc., as may exist in the country. These decrees have been strongly protested by the diplomatic representatives of the foreign interests, and, as a matter of fact, are all subject to further modification, parliamentary approval, etc., but nevertheless they constitute a source of uneasiness to present investors and tend to discourage new investments.

Russia.—The chaotic condition of the petroleum industry in Russia is well illustrated in a translation by the Russian division of the U. S. Bureau of Foreign and Domestic Commerce, from which the following is taken:

The three main petroleum regions of Russia are Baku, Grozny, and Emba. At the beginning of October, 1917, stocks of petroleum in Russia amounted to 200,000,000 poods (24,000,000 bbl. of 42 gal.) of which 150,000,000 poods (18,000,000 bbl.) was stored in Volga River warehouses. These were the main distributing centers for the interior markets, and in 1917 the distribution of petroleum products was more or less successful, though the disruption of railroad transportation was felt. In 1918 conditions changed radically. At the end of 1917 the Grozny region was lost by the Bolsheviki, and in August, 1918, the Baku region. At the same time the unpreparedness of the Caspian steamers, the scarcity of food, and the financial crisis in the Baku region before it was lost to the Bolsheviki resulted in the transportation of only 74,000,000 poods of petroleum products into Astrakhan during the 1918 season of navigation; i.e., 25 per cent. of the amount usually received there. The Czecho-Slovak insurrection reacted unfavorably on the movement of petroleum products up the Volga River, and consequently during the navigation season of 1918 only 84,000,000 poods of petroleum products were shipped up the river, against 398,000,000 poods in 1917.

The loss of the oil regions brought to the Bolsheviki the possibility of an oil famine. The total supply of oil in 1918 equaled 95,000,000 poods, of which about 30,000,000 poods was stored in the warehouses on the Volga. For the needs of all regions there could be had only 7,500,000 poods (probably owing to transport difficulties), though the estimated minimum requirement was 17,000,000 poods. In 1917 the requirement for the central region alone was 75,000,000 poods. Consequently, many establishments were not supplied with oil and their work was suspended. The distribution of kerosene to the individual consumer also ceased. In 1918–19 liquid fuel amounting to 85,000,000 poods was used—for railroads, 40,000,000 poods; for Volga steamers, 18,000,000 poods; and for industry, 27,000,000 poods. For the next operating year (May, 1919, to May, 1920) the supply of oil fuel did not exceed 7,000,000 poods. The recapture of Emba, Grozny, and then Baku again changed the state of affairs for the better. In the Ural-Emba field 14,000,000 poods of oil products were captured; in Baku, 300,000,000 poods; and at the end of navigation in 1920, 150,000,000 poods of petroleum products had been shipped up the Volga River.

The following table gives the 1920 production of crude petroleum in the Baku oil fields by months, according to the information of the main petroleum committee. (Conversions at 8⅓ poods to the barrel have been added to the original table.)

Months.	Production in Six Fields.		Production in Four Main Fields.	
	Poods.	Barrels.	Poods.	Barrels.
January	18,200,000	2,184,000	9,800,000	1,176,000
February	17,500,000	2,100,000	9,000,000	1,080,000
March	19,300,000	2,316,000	9,900,000	1,188,000
April	17,900,000	2,148,000	9,200,000	1,104,000
May	16,500,000	1,980,000	8,400,000	1,008,000
June	15,100,000	1,812,000	7,500,000	900,000
July	13,300,000	1,596,000	6,100,000	732,000
August	12,200,000	1,464,000	5,500,000	660,000
September	10,600,000	1,272,000	5,000,000	600,000
October	7,200,000	864,000	4,000,000	480,000
November	4,100,000	492,000	2,900,000	348,000
December	5,400,000	648,000	3,000,000	360,000
Total	157,300,000	18,876,000	80,300,000	9,636,000

After April, 1920, when the Bolsheviki took control of the Baku oil fields, there was a steady falling off of the production. Likewise the number of producing wells decreased rapidly. In 1917 their number was over 3000; in January, 1920, they numbered 1800; on Sept. 1, 1340; and on Jan. 1, 1921, 828. Among these are included the wells that became flooded, their number being about 15 per cent. of the total.

The drilling of oil wells is nearly at a standstill. In 1919 there were drilled on an average 3500 ft. per month; in 1920 1540 ft. was drilled. In December drilling stopped altogether.

The decrease in production in 1920 is explained by the falling-off of the workmen in efficiency and in numbers, there being a shortage of 487 on July 1, 1920, of 1291 on Aug. 1, and of 2903 on Jan. 1, 1921. There were 22,800 employees in the Baku oil fields on Aug. 1, 1920, and 16,680 on Jan. 1, 1921. In this region there was an acute shortage of foodstuffs, clothing, shoes, labor, and materials. Most of the wells are not being worked and they are threatened with flooding.

The quantity of Baku petroleum products stored on Aug. 1, 1920, amounted to 243,600,000 poods, of which 107,200,000 poods (12,864,000 bbl.) was crude petroleum; 118,200,000 poods (13,133,000 bbl.) was residues; 10,400,000 poods (1,300,000 bbl.) was kerosene; 500,000 poods (67,000 bbl.) was benzine; and 200,000 poods (27,000 bbl.) was gasoline. On Jan. 1, 1921, the total quantity stored was 138,480,000 poods.

The following table gives the production, shipments, number of workmen and of wells, wells being drilled, and total amount of drilling in the Grozny region in 1913, 1917, 1918, 1919, and 1920 [Conversions from poods to barrels (at 8⅓ poods to the barrel) and from sazhens to feet have been added to the original table.]

Periods.	Production.		Shipments.		Employees	Wells.	Wells Being Drilled.	Total Amount of Drilling.	
	Poods.	*Barrels.*	*Poods.*	*Barrels.*	*No.*	*No.*	*No.*	*Sazhens.*	*Feet.*
1913	73,659,000	8,839,100	.....	.....	6,534	229	.....	29,482	206,374
1917	107,816,000	12,937,900	72,393,000	8,687,200	10,265	393	.....	18,214	127,498
1918	25,217,000	3,026,000	4,939,000	592,700	2,206	41	.....	20	140
1919	37,738,000	4,528,600	28,524,000	3,422,900	1,746	43	.....	36	252
1920	47,878,000	5,745,300	52,014,000	6,241,700	.....	.....	.....	.....	.....

Thus in 1920 there was produced 10,000,000 poods of crude petroleum more than in 1919, but the number of workmen increased in much greater proportion. The Bolsheviki shipped more than was produced in 1920, partly from old stocks. The shipments of oil went by rail in 1920; in 1916 and 1917, 50 per cent. was piped to Petrovsk and shipped by sea. There was an acute shortage in 1920 of food, equipment, and housing facilities.

The production of the Emba wells was hindered by the lack of storage facilities and also by shortage of labor and materials. During 1920 there were no shipments. The production in 1917 was 15,600,000 poods (1,872,000 bbl.); in 1918, 8,900,000 poods (1,068,000 bbl.); in 1919, 1,600,000 poods (192,000 bbl.); and in 1920, 3,735,000 poods (448, 200 bbl.).

The total production of crude petroleum in Russia during the last four years was as follows: 1917, 525,600,000 poods (63,072,000 bbl.); 1918, 226,400,000 poods (27,168,000 bbl.); 1919, 264,600,000 poods (31,752,000 bbl.); 1920, 211,913,000 poods (25,429,600 bbl.) including some secondary regions, which furnished about 3,000,000 poods (360,000 bbl.).

Figures regarding petroleum products in storage are available only for Oct. 1, 1920 (in Baku, Grozny, and Emba), and are as follows: Crude petroleum, 130,500,000 poods (15,660,000 bbl.); residues, 121,300,000 poods (13,478,000 bbl.); kerosene, 11,700,000 poods (1,462,500 bbl.); lubricating oil, 4,300,000 poods (525,700 bbl.); ligroin, 1,900,000 poods (237,500 bbl.); pyronaphtha, 2,000,000 poods (250,000 bbl.); solar oil, 30,000 poods (3,700 bbl.); benzine, 7,600,000 poods (1,013,300 bbl.); gasoline, 300,000 poods (40,000 bbl.); other products, 30,200,000 poods (3,606,000 bbl.)—a total of 309,830,000 poods (36,276,700 bbl.).

Asia

Borneo.—W. H. Emmons and J. W. Gruner have published in the *Engineering and Mining Journal* a description of the Sanga Sanga oil field. The Borneo oil field may be regarded as a great Tertiary monocline, with smaller fold developed on it. The most eastern fold is the Sanga Sanga anticline. It contains the principal producing wells. Three kinds of oil are produced in the field, heavy, light and a paraffin oil. The heavy oil is found at depths of 30 to 290 meters from the surface, the light oil at 200 to 400 meters, and the paraffin oil at 300 to 500 meters. The northwest or mountain-ward side of the fold, a steep limb, yielded more light oil than the southeast.

Dutch East Indies.—Production in the Dutch East Indies remained at the usual level of 16,000,000 bbl. The development of the Djambi field has been allotted to the Dutch Shell in spite of protest by the United States.

India.—British India produced 8,500,000 bbl. in 1920. In the oil fields of upper Burma production continues to increase. The product of 1919 exceeded that of any recent year. The upper Chindwind field gave 230,000 bbl. in 1919, a gain from 90,000 in 1918. The Singu (Chauk) field increased still more rapidly, yielding an increase of 800,000 bbl. in 1919.

Japan.—By the use of rotary drilling and every other modern improvement in exploitation methods, Japan was able to keep production up to 2,213,083 bbl. in 1920, compared with 2,120,500 bbl. in 1919. This product includes a small amount from Formosa.

Persia.—Production by the Anglo-Persian Co. is gradually increasing. In 1918, 4,000,000 bbl., in 1919, 6,000,000, and in 1920, 6,400,000 bbl. was produced. Transporting and refining facilities are improving under the vigorous administration of this formidable organization. The conditions of occurrence of oil in Persia and adjoining territory, and the political aspects affecting its development are described in detail in an article by E. M. Spieker in the *Engineering and Mining Journal* of Aug. 14, 1920.

Important diplomatic correspondence between the United States and Great Britain followed an agreement between that nation and France relative to the division of oil territory in Mesopotamia, which brought to attention the rights involved by the "Chester Project," including a concession to United States citizens for oil lands in that region, the entire completion of which was temporarily interrupted by the war.

The new oil refinery of the Anglo-Persian Oil Co. at Swansea is now practically ready to begin operations. The company states that it expects to begin refining oil in February or March, 1921. The refineries are located at the village of Skewen, about four miles from the port of Swansea, among the hills. The company has leased from the Swansea Harbor Trust on long lease fifty acres of land lying adjacent to the King's Dock, where there have been erected four huge sheet-iron tanks with a capacity of 2,500,000 gal. each. These tanks are connected with the adjacent dock and jetty by underground pipes.

The initial capacity of the plant is stated to be 12,000 to 15,000 tons of oil per week. The capacity, it is expected, will be doubled within two years. The crude oil will be brought in bulk from the Persian fields and from other sources as they are available. While the primary object of the company is to refine for fuel purposes, it plans ultimately to enter the field of high-test refining and to turn out both oil for lighting and gasoline.

Philippine Islands.—The deposits of petroleum and natural gas thus far located in the Philippines have been described in previous volumes of this series.

During 1920 the Standard Oil Co. began definite exploitation work on the island of Luzon and will build a refinery if production proves adequate. A recent bulletin by the Philippine Bureau of Science[1] gives a very detailed review of the conditions of occurrence of oil in the Philippine

[1]Published in *Oil and Gas Jour.*, May 6, 1921.

Islands. The prospect for a commercial development is considered promising.

Turkestan.—It is stated in a recent issue of *Oil News* that the Chinese Cabinet has sanctioned the exploitation of the oil reserves of Chinese Turkestan by a company registered under the title of the Chinese Turkestan Petroleum Co., the Chinese name of which is "Funkungsze." The company is a British undertaking and its English experts have already begun drilling operations in two districts.

AFRICA

Egypt.—The discovery and exploitation of petroleum fields along the Egyptian Red Sea coast would under normal conditions render the country self-sufficing in gasoline, and the supply probably will be further increased from new oil fields in the Sinai Peninsula. But Egyptian crude oil is high in volatile content and yields not more than one-fifth of the country's requirements in kerosene.

The production of petroleum in Egypt in recent years is as follows:

	Metric Tons.
1911	2,793
1912	27,962
1913	12,786
1914	99,680
1915	30,054
1916	57,743
1917	136,845
1918	281,885
1919	224,300

The capacity of the Anglo-Egyptian Oilfields, Ltd., refinery has been increased to 1500 tons per day.

During the winter season 1919–1920 there was considerable increase in prospecting activity and several geological parties were in the field. Licenses have been granted over new ground, but owing to the difficulty of obtaining oil-well supplies actual boring has not yet commenced.

The Egyptian Government has maintained its geological investigations of structures and mapping of likely oil areas, which are extensive on both sides of the Gulf of Suez. Preparations are being made to extend the scope of these investigations and to include drilling operations and the erection of a small refinery.

Union of South Africa.—Following the suggestions made by Dr. H. Cunningham Craig after his visit to South Africa several years ago, work is in progress with a view to developing the oil shales at Kromhoekin, in the Wakkerstroom district in the Transvaal. Mr. Trevor, Inspector of Mines, Pretoria, finds that his analysis showing 25 gal. to the ton has been increased to 31 gal. when tested in Glasgow. It is also stated that the quantity of oil shale is ample to justify a plant.

Australia

Queensland.—Natural gas has been found in several wells at Roma. The first were water wells. The fourth, drilled in 1919, first showed gas at 3602 ft. and again in sandstones at 3665 and 3677 ft. When the pressure of the water column in the well was reduced by 880 ft. the gas pressure blew the water out of the hole and showed a large gas well, yielding 6,000,000 cu. ft. per day. The gas shows 1.2 pints of gasoline per 1000 cu. ft. It is planned to save this by an absorption plant.

Oil Shales

During the year 1920 the interest in the rich oil shales of Colorado, Utah, California and certain eastern states gradually advanced in the direction of commercial development. Several plants of commercial proportions neared completion during the year in Utah and Colorado, and actually began selling shale oil in 1921. In California the Day plant was sold near the close of the year to a Texas corporation, and increased development was begun. It became evident that the shale tract at this plant, known as the Shuman anticline, is one of the interesting tracts of the country. Careful prospecting has given 28 gal. of oil to the ton for the entire hill, which extends 125 ft. above the ground-level. Oil wells in the vicinity show the shale to be over 2000 ft. deep.

In Nevada the Catlin plant at Elko is being developed for paraffin wax. The other shale deposits in that region have not proved to be sufficiently persistent. The shale deposits of Clay County, Kentucky, are receiving careful attention and a plant is in construction.

In New Brunswick, Nova Scotia, a plant of the Wallace process was put in operation in 1921, and all reports from it are thus far satisfactory. This will doubtless lead to the completion of the similar plant on White River, Utah.

The Western Shale Oil Co. erected a Galloupe plant of 10 tons daily capacity near Watson, Utah, which produced regularly until destroyed by fire. The plant gave a slightly greater yield per ton than is usually shown by laboratory analyses of the shale in question. The utilization of the coke in the spent shale as a direct source of heat is a particularly well-arranged feature of this process.

In the Grand Valley and DeBeque region of western Colorado seven commercial plants are about complete, and two began shipping oil to the Apex Refining Co. during the early part of 1921.

Natural Gas

The Census Office has just published a statement of the total production of natural gas in 1919 and its value at the wells, showing that

1,276,152,627,000 cu. ft. was the total production, and the value at the well $155,847,905. It has offered an interesting comparison with the year 1909, in which year the production and value were as follows: 559,800,490,000 cu. ft., value $67,605,397. The increase from 1909 to 1919 was 118.2 per cent.

Natural-gas Gasoline.—According to the Bureau of the Census, 453,949,852 gal. of natural-gas gasoline was produced in 1919, valued at $78,752,824.

COMPARATIVE STATISTICS, PETROLEUM AND NATURAL GAS, 1919 AND 1909

	1919.	1909.	Per Cent. Increase.
Number of producing enterprises	9,814	7,793	25.9
Number of petroleum and natural-gas wells	260,672	166,320	56.7
Number of natural-gas-gasoline plants	1,118	(a)	.....
Persons engaged	125,077	59,085	111.7
Proprietors and firm members, total	14,223	16,213	*12.3
Number performing manual labor	1,989	2,155	*7.7
Salaried employees	17,649	6,128	188.0
Wage earners average number)	93,205	36,744	153.7
Power used (horsepower)	1,821,367	1,221,969	49.1
Capital	$2,421,485,942	$683,268,497	254.4
Principal expenses—			
Salaries	33,468,368	7,241,881	362.2
Wages	134,520,747	27,091,650	396.5
Contract work	68,663,659	16,736,510	310.3
Supplies and materials (b)	223,872,364	49,835,890	349.2
Fuel and power	20,767,040	1,444,595	1,337.6
Royalties and rents	106,458,518	21,282,820	400.2
Taxes	38,690,629	2,576,986	1,401.4
Products, total value (c)	$1,001,316 060	$185,416,684	440.2
Petroleum—			
Barrels (42 gallons)	360,016,400	171,559,394	109.8
Value at well	$694,107,577	$117,696,529	489.7
Natural gas—			
1,000 cubic feet	1,276,152,627	559,800,490	118.2
Value at well	$155,847,905	$67,605,397	130.5
Natural-gas gasoline—			
Gallons	453,949,852	(b)	.....
Value at plant	$78,752,824	(b)	.....

* Denotes decrease.
(a) Not available.
(b) Includes gas purchased for use as material and for re-sale.
(c) Includes value of minor products and amount received for work done and power sold.

PHOSPHATE ROCK

By Wm. H. Waggaman

The situation in the phosphate-rock industry in 1920 presented a sharp contrast with its condition in 1919. While the statistics are not entirely complete, the figures as far as they are available show that practically every phosphate-producing nation without exception increased its output during the past year. In several cases the production actually exceeded that of 1913, which was the banner year for the phosphate industry. The total marketed output as far as can be learned at present was 6,509,957 metric tons as against a production the previous year of 4,125,905 tons. The unusual conditions brought about during the post-war period, however, have not altered the relative commercial value of the various deposits of the world, which in the order of their present importance may be grouped as follows:

The phosphates of the United States, including those of great value and extent in Florida, Tennessee, South Carolina, and the Western States, Utah, Idaho, Wyoming, and Montana, and deposits of less importance in Kentucky and Arkansas; the deposits of Northern Africa, Algeria, Tunis, Egypt, Morocco; the deposits of the Pacific and Indian

TABLE I.—PRODUCTION OF PHOSPHATE IN THE WORLD (a)
(In metric tons)

	1913.	1914.	1915.	1916.	1917.	1918.	1919.	1920.
Algeria	461,030	(e)355,140	(e)225,891	(e)389,211	(e)202,539	(e)198,539	(e)242,186	502,931
Angaur Island.	90,000	(e)60,000	30,000	30,000	(c)	.....	30,000	30,000
Belgium	219,420	105,330	16,350	77,740	138,800	61,700	90,970	.....
Canada	349	866	197	184	135	127	24	.....
Christmas Island	150,005	95,234	24,119	44,209	89,889	.....	.....	
Dutch W. Indies, Aruba	38,150	(e)86,572	51,000	14,468	3,639	.....	.....	.....
Curacao	1,850	(e)11,219	(e)32,915					
Egypt	101,311	71,945	82,998	125,008	115,732	31,147	29,365	(e)145,072
France	298,859	270,000	145,000	25,000	(c)	.....	103,869	.....
Japan	19,047	38,252	57,723	114,389	121,609	191,722	122,868	.....
Nauru Island	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000
Makatea	82,000	72,925	71,724	39,285	32,259	(b)40,000	(b)40,000	(b)40,000
Norway	757	750	1,901	2,236	1,832	4,562	.....	.....
Ocean Island	250,000	.....	.....	70,000	.....	.....	.....	200,000
Russia	25,000	15,000	.....	.....	.....	.....	.....	.....
Spain	3,548	8,312	9,080	14,111	28,148	43,303	25,035	(b)40,000
New Zealand	(b)10,000	(b)10,000	(b)10,000	(b)10,000	(b)10,000	(b)10,000	(b)10,000	(b)10,000
Tunis	2,284,678	1,427,161	1,389,074	1,695,295	999,326	818,962	815,385	1,222,000
United States	3,068,604	2,752,971	1,873,625	2,177,292	2,652,776	2,530,861	2,465,203	4,170,056
Total	7,254,608	5,531,696	4,066,597	4,969,428	4,544,684	4,050,923	4,125,905	6,509,957

(a) Based on marketed output. (b) Estimated. (c) Statistics not available. (e) Exports.

Oceans, including those of Ocean, Christmas, and Pleasant Islands, and islands of the Marshall and Society groups; the phosphates of Russia, Belgium, and France; the Peruvian guano deposits; and a number of other smaller deposits in various other countries.

The world's output of phosphate rock based on material marketed for the past eight years is given in detail in Table I.

United States

Ever since the discovery of phosphate rock in South Carolina in 1868, the United States has been the foremost phosphate-producing nation in the world. Although we have mined and marketed over 40,000,000 tons of phosphate rock during the past 20 years, and lost or wasted fully as much again, owing to our methods of separating the phosphate from its impurities, our known reserve supplies of this mineral are constantly being increased by new discoveries. The latest estimated amount of high-grade rock and its low-grade equivalent is placed at fully 10,500,000,000 tons. Much of this reserve supply, however, is located in regions far removed from the fertilizer market and where transportation facilities are relatively poor. The production of phosphate rock in 1919 according to the figures of the U. S. Geological Survey exceeded that of any other year on record, reaching the stupendous total of 4,103,-982 long tons. This tonnage was in marked contrast with 1919, when only 1,815,690 tons was produced and 2,426,142 tons marketed. The great increase in output during 1920 was due to a number of causes, chief among which were the stimulation of American agriculture, caused by the added value of farm products, and the great demand for phosphates in European countries.

While most of the phosphate rock consumed in this country is manufactured into acid phosphate, there is also a large demand for finely ground raw rock phosphate to be applied directly to the soil. Complete statistics on this amount were not received for 1920, but as far as can be learned, the quantity thus consumed amounted to about 90,000 tons. In addition to the phosphate consumed for fertilizer purposes a considerable tonnage was also used in the manufacture of elementary phosphorus, ferro-phosphorus, in the production of baking powder, in manufacturing rust-proofing compounds, and the relatively pure chemicals. The quantity used for these purposes was well over 200,000 tons.

The production and value of phosphates from the various phosphate fields in this country for the past five years are given in Table II, and the total production, imports, exports and domestic consumption for the past 10 years are shown in Table III. In Tables IV and V the imports and exports of various fertilizer materials in the United States are given.

TABLE II.—PRODUCTION OF PHOSPHATE ROCK IN THE UNITED STATES
(In tons of 2240 lb.)

Phosphate.	1917.		1918.		1919.		1920.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
Florida soft rock	.....	.....	17,736	$212,832	8,715	$104,580	13,953	$190,551
Florida hard rock	93,339	$457,881	42,840	310,590	101,300	962,350	400,249	4,526,191
Florida land pebble	2,016,462	5,242,801	2,141,950	5,997,460	1,159,419	6,956,514	2,955,182	14,748,620
Total, Florida	2,109,801	$5,700,682	2,202,526	$6,520,882	1,269,434	$8,023,444	3,369,384	$19,464,362
S. Car. land rock	45,541	$188,358	51,387	$231,242	54,851	$329,106	44,141	$367,209
S. Car. river rock	.....	.....	.....	.....	.....	.....	.....	.....
Total, S. Carolina	45,541	$188,358	51,387	$231,242	54,851	$329,106	44,141	$367,209
Tennessee	439,022	$1,819,307	430,288	$2,581,727	473,985	$3,791,880	634,848	$4,943,995
Other states	16,379	45,304	11,342	56,710	17,420	139,360	55,609	304,006
Total, U. S.	2,610,743	$7,753,651	2,695,543	$9,390,562	1,815,690	$12,283,790	4,103,982	$25,079,572

TABLE III.—STATISTICS OF PHOSPHATES IN THE UNITED STATES
(In tons of 2240 lb.)

Year.	Production	Imports.	Exports. (a)	Domestic Consumption.
1911	3,216,993	16,153	1,246,577	1,980,569
1912	3,166,032	28,821	1,206,520	1,988,333
1913	3,062,975	26,408	1,366,508	1,724,525
1914	2,752,971	15,078	964,114	1,839,057
1915	1,873,625	5,359	253,421	1,625,435
1916	2,177,292	4,612	243,678	2,081,467
1917	2,610,743	*Nil.*	166,358	2,653,829
1918	2,695,543	*Nil.*	143,891	2,346,869
1919	1,815,690	*Nil.*	434,251	1,991,891
1920	4,103,982	*Nil.*	1,070,012	3,033,970

(a) Neglecting the insignificant exports of foreign products.

TABLE IV.—IMPORTS OF FERTILIZERS INTO THE UNITED STATES
(In tons of 2240 lb.)

	1917.		1918.		1919.		1920.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Ammonium sulphate	7,263	$649,125	2,993	$425,881	2,369	$314,266	1,994	$247,495
Phosphates (crude)	*Nil.*	.....	*Nil.*	.....	.....	.....	*Nil.*	.....
Apatite	*Nil.*	.....	1	30	.....	.....	*Nil.*	.....
Basic slag	*Nil.*	.....	.....	.....	.....	.....	*Nil.*	.....
Bone dust	10,519	308,497	5,183	154,231	6,116	207,885	18,266	966,255
Guano	6,500	140,101	8,206	280,544	7,017	255,992	53,790	4,583,313
Kainit	*Nil.*	.....	*Nil.*	.....	51,274	291,482	374,732	8,268,031
Manure salts, tons	190	8,872	*Nil.*	.....	40,542	1,271,628	317,911	10,730,274
Potash (muriate)	737	196,585	379	102,109	20,716	1,783,917	121,602	12,703,858
Potash (sulphate)	203	21,702	90	15,329	1,263	188,590	15,184	2,343,431
Nitrate of soda	1,555,839	60,283,900	1,845,192	90,379,285	407,459	19,558,961	1,321,922	63,129,196
All other fertilizers	.....	4,456,363	.....	4,018,013	72,620	4,294,056	140,727	6,717,277
Cyanamid	.....	.....	26,191	1,360,557	62,121	2,717,693	71,305	4,541,870

(a) Bureau of Foreign and Domestic Commerce.

TABLE V.—EXPORTS OF FERTILIZER MATERIALS
(In tons of 2240 lb.)

	1919.		1920.	
	Quantity.	Value.	Quantity.	Value.
Superphosphates	86,852	$2,781,151	80,993	$2,949,629
Sulphur or brimstone, crude	224,712	6,325,552	477,450	8,994,350
Phosphate rock, not acidulated:				
High-grade hard rock	218,539	2,321,352	344,896	4,496,457
Land pebble	128,860	904,308	693,355	5,593,814
All other	86,852	2,781,151	31,761	500,904
All other fertilizers	188,253	14,533,946	205,366	15,581,658
Ammonium sulphate	.....	.....	59,566	7,433,350

(a) Bureau of Foreign and Domestic Commerce.

Florida.—The phosphate industry in Florida during 1920 was in marked contrast with its condition in 1919 when labor troubles cut down production to the lowest point it had reached in twenty years or more. Twenty-six companies were operating at almost full capacity and there was an excellent market for the entire product.

The output from the hard-rock regions in 1920 amounted to 400,249 long tons, as against a marketed output of 307,919 tons and an actual production of only 101,300 tons in 1919. In addition to this high-grade hard-rock phosphate there was produced also 13,953 tons of soft phosphate, a material occurring in the hard-rock deposits which is sold for direct application to the soil. The average price of the hard rock during the year was $11.30 per ton and that of the soft phosphate $13.70 per ton.

In the land-pebble regions the production in 1920 broke all previous records, amounting to 2,955,182 long tons, which was considerably more than double the production in 1919, when 1,159,419 tons was mined and 1,435,806 tons marketed. The average price of the pebble phosphate for the year was $5.00 per ton. The statistics of Florida phosphates are given in Table VI.

TABLE VI.—STATISTICS OF FLORIDA PHOSPHATE
(In long tons)

Year.	Production.			Total Shipments.	Domestic Consignment.	Exports.
	Hard Rock.	Pebble.	Total.			
1913	510,811	2,043,403	2,554,214	2,554,214	1,130,764	1,363,450
1914	309,689	1,787,597	2,138,891	2,138,891	1,209,898	928,993
1915	42,962	1,368,282	1,411,244	1,411,244	1,158,052	253,192
1916	81,071	1,601,061	1,682,132	1,520,706	1,317,270	203,435
1917	93,339	2,016,462	2,109,801	2,096,670	1,963,524	133,146
1918	42,840	2,141,950	2,202,526	2,067,230	1,944,804	122,336
1919	101,300	1,159,419	1,250,719	1,339,962	977,560	362,402
1920	400,249	2,955,182	3,355,431	3,355,431	2,317,180	1,038,251

Tennessee.—There are three distinct types of Tennessee phosphate, namely, the brown, the blue, and the white rock. Only the first two have so far proved of much commercial importance.

In the early part of 1920 twelve companies were actively engaged in mining phosphate rock in Tennessee, but towards the latter part of the year a number of plants were shut down entirely while others were running only intermittently. The total production amounted to 634,848 tons as against 473,985 tons in 1919.

The brown rock, or Ordivician, continues to be the most actively exploited, and more modern methods of mining are enabling the operators to recover much material which was formerly wasted. Also many deposits of disintegrated phosphate rock can now be mined which were previously regarded as of little or no value. The most important localities where mining is now being conducted are in the vicinities of Columbia and Mt. Pleasant in Maury County, near Centerville in Hickman County, and in the vicinity of Wales Station in Giles County. The rock ranges in grade from 55 to 78 per cent. bone phosphate of lime, the average phosphate content being about 72 per cent. The production of brown phosphate rock in 1920 amounted to 556,177 tons as against 475,475 tons in 1919. The average price of the brown rock was $7.96 per ton.

The blue, or Devonian, phosphate is being mined near Gordonsburg in Lewis County, and also in the Centerville region. The average grade of the blue rock is also about 72 per cent. bone phosphate of lime. In 1920 there was produced 78,671 tons of blue phosphate as against 58,550 tons in 1919. The average price of the blue phosphate during the past year was $6.59 per ton.

The deposits of white phosphate occurring in Perry and Decatur counties resemble somewhat the hard-rock phosphate deposits of Florida. While some of this white phosphate ranks with the highest-grade phosphate in the world, the occurrences are so irregular and the deposits as a whole contain so much chert that it has not proved profitable to mine them in competition with the more regular deposits of brown and blue rock. No production of white phosphate has been reported for a number of years.

South Carolina.—The nodular phosphates of South Carolina were the first important deposits of this mineral discovered in the United States, and for a long time were the most actively exploited. The South Carolina phosphate deposits are by no means exhausted, but the Florida and Tennessee deposits have both far outstripped them in production. The expense of mining has discouraged any further extensive development in South Carolina during recent years, but since much capital is invested in mining equipment the necessity of paying interest on this

investment will no doubt cause these deposits to supply an appreciable tonnage to the fertilizer industry for some time to come. The output of phosphate from the South Carolina fields, however, fell off considerably in 1920, only 44,141 tons being produced as against 60,823 tons in 1919. This was practically the only phosphate field showing a production less than that of 1919. The average value of the South Carolina phosphate in 1920 was $8.32 per ton, which was over 60 per cent. greater than the previous year.

Utah, Idaho, Wyoming, and Montana.—The phosphate deposits of these Western States are by far the most extensive in the world, the latest estimate of the amount of high-grade rock in these regions showing a reserve supply close to six billion tons. This tonnage is continually being enhanced by fresh discoveries as the survey of the phosphate area is continued, an extension of this field having recently been traced into Canada. The rock, which is of Carboniferous age, occurs in beds of a few inches to 6 ft. or more in thickness, and has an average content of 70 per cent. bone phosphate of lime. While most of the phosphate occurs on Government land, provision has been made for the leasing of such land on the payment of royalty to the Government. The minimum royalty is 2 per cent. of the gross value of the output, and a rental of 25 cts. an acre will be charged for the first year, 50 cts. an acre for each year from the second through the fifth year, and $1 an acre annually thereafter. No leases will ge given for more than 2560 acres. The high price of phosphate rock during 1919 and 1920 encouraged private enterprises to go ahead with the development of some of these deposits and one of the outstanding features of the past year was the great increase in the output of phosphate rock from the western fields. According to the figures of the U. S. Geological Survey the production in 1920 amounted to 55,609 tons, an increase of 223 per cent. over the output in 1919, when only 16,935 tons was produced. The average price per ton of the western phosphates in 1920 was $4.12 per ton f.o.b. mines. Five companies were actively engaged in mining western phosphate in 1920, but the most extensive development work was being done by the Anaconda Copper Co., which has purchased a group of phosphate claims in the vicinity of Soda Springs said to contain 200,000,000 tons of rock. This company has been shipping the phosphate to its Washoe smelter and producing a concentrated superphosphate for the middle-western fertilizer market. Because of the very cheap sulphuric acid available at Anaconda it is believed that available phosphoric acid can be produced at a price far lower than at any of the eastern fertilizer factories.

Kentucky and Arkansas.—Although a number of deposits of phosphate similar in appearance and grade to the brown rock of Tennessee have been

discovered in Kentucky, they have so far proven of rather limited extent. No details of the output from the Kentucky deposits have been reported for 1920.

The Arkansas deposits are much lower in grade than the phosphates of Kentucky and Tennessee, and while the beds are fairly extensive they have not been mined since 1915.

Phosphates in Foreign Countries

Africa

Next in importance to the deposits of the United States are the phosphates of northern Africa. Mining operations have been very extensive in Tunis and Algeria since 1899 and the phosphates of Egypt are assuming a greater importance each year.

Vast deposits of phosphate have also been discovered in Morocco in the districts of El Boroudj and Oned-Zem about 80 miles south-southeast of the port of Casa Blanca. The phosphates belong to the Tertiary period, and while at first reported to be of a grade rivaling that of the Florida deposits, the average phosphoric-acid content was later found to be considerably lower. A great deal of development work will have to be done and a railroad built before the Moroccan phosphates appear on the market in any quantity.

While the phosphates of Africa are somewhat lower in grade than those of Florida, Tennessee, and our Western States, their close proximity to the European and Japanese markets has made them in recent years the chief source of phosphate fertilizer for European and Asiatic nations. Increased freight charges will probably aid the development of the African phosphates, since the haul to the European market is comparatively slight as compared with the distance between America and Europe.

While complete statistics are not yet available giving the production from the African phosphate fields, both Egypt and Algeria showed notable increases in production. In fact the output from these fields was greater than in any other single year on record. The total production of phosphate in Africa during 1920 was 870,002 metric tons as against 1,135,996 tons in 1919.

Tunis.—In normal times Tunis has an annual production of phosphate rock second only to that of Florida, but during the latter years of the war the production fell off to less than half the normal output. The deposits are controlled largely by French capital and up to the time of the war they were being mined at an ever increasing rate.

The French Government allocated the Tunisian production in 1919 as follows: France, 700,000 tons; England, 274,000 tons; Italy, 355,000

tons; Portugal, 14,700 tons; Belgium, 3600 tons; Switzerland, 5500 tons; Spain, 734,600 tons; making a total of 1,400,000 tons. Only 58 per cent. of this amount, however, was actually produced.

The main phosphate district of Tunis is in the vicinity of Gafsa, which is connected with the port of Sfax by a railroad 150 miles long. The phosphate occurs in gigantic lenses of considerable thickness and ranging in grade from 53 to 68 per cent. bone phosphate of lime. The mining is done by open cuts as well as by tunnels. The Société de Phosphate de Gafsa, which controls all the phosphate in the Gafsa region, is the largest single producer of phosphate in the world. Up to 1914 its annual output was constantly being increased. The other companies in Tunis are the Sociétés des Phosphates Tunisiens and Compagnie des Phosphates du Dyr. The total output in 1920 was 1,222,000 tons, which is a considerable increase over that of 1919, when 815,385 tons was produced.

Algeria.—The Algerian phosphate deposits are of the same general type as those of Tunis and of a similar grade, although the phosphate deposits of Algeria have not been developed to the same extent as the Tunisian fields. Their output based on the material marketed has been well over a quarter of a million tons annually for more than a decade. In 1920, however, the production amounted to 502,931 metric tons, which is an increase of more than 60 per cent. over that of 1919, when 242,186 tons was reported. The Algerian phosphates are mined by four French companies, the most important of which is the Compagnie des Phosphates de Constantine.

Egypt.[1]—Deposits of phosphate occurring as beds in sedimentary strata are widely distributed in Egypt. They are very similar in character to those of Algeria and Tunis and present a field of considerable economic importance. The land now let under mining lease forms a very small proportion of the total area known to contain phosphates, so that there is ample opportunity for prospecting enterprise.

The localities in which phosphate is at present being mined are: the Safaja district near the Red Sea coast, the Kossier district near the Red Sea coast, and the Sebaia district on the east bank of the Nile.

The rock phosphate is either shipped raw in bulk or manufactured into a finished fertilizer, of which two kinds are at present made in Egypt, namely, "Ephos Basic Phosphate" and "Tetraphosphate;" these are exported in bags.

Prior to the war the greater part of Egypt's phosphate production was shipped to Japan, which took 75,565 tons in 1914. During hostilities the quantities exported fell off owing to high freight-rates and the impos-

[1] Report furnished by the Department of Mines and Quarries, Egypt.

sibility of obtaining sufficient shipping for the purpose. In 1920, however, the exports increased greatly, amounting to 145,072 metric tons, which was more than double those of 1913 and nearly twice as high as the exports of 1919, when 78,425 tons was shipped. Of the 1920 exports 48,102 tons went to Japan, 47,520 to Italy, 15,800 to Australia and New Zealand, 15,803 to British possessions, 6688 to Spain, and 6014 to France.

The phosphate produced in the Nile Valley is the lowest grade and is shipped from the port of Alexandria. The Red Sea districts produce the better qualities, which are despatched from the ports of Safaja and Kossier. Port Safaja is a deep-water anchorage and has an installation for mechanical loading.

Figures, as far as they are available, showing the shipments of African phosphate are given in Table VII.

TABLE VII.—SHIPMENTS OF PHOSPHATE ROCK FROM ALGERIA, TUNIS AND EGYPT
(In metric tons)

Year.	Algeria.	Tunis.	Egypt.	Year.	Algeria.	Tunis.	Egypt.
1900	277,896	171,288	.....	1911	332,897	1,446,633	12,013
1901	278,185	178,019	.....	1912	388,515	1,923,000(b)	70,918
1902	265,964	266,553	.....	1913(a)	438,601	1,984,880	64,183
1903	301,112	360,521	.....	1914(a)	355,140	1,427,161	86,571
1904	344,969	457,133	.....	1915	225,891	1,087,816	33,245
1905	347,747	529,645	.....	1916	380,211	1,034,498	20,526
1906	302,262	747,303	.....	1917	202,539	613,440	27,015
1907	343,085	956,958	.....	1918	198,539	818,962	9,346
1908	362,890	1,270,020	.....	1919	242,186	815,385	78,425
1909	351,491	1,224,822	.....	1920	502,931	900,000	145,072
1910	319,069	1,286,262	2,397				

(a) Figures furnished by Charles Michel, Paris. (b) Estimate.

Islands of the Pacific and Indian Oceans

The phosphate deposits which occur in several islands of the Pacific and Indian oceans are of the highest grade yet discovered. The most important phosphate-producing islands of the Pacific are Ocean Island (English) of the Gilbert group, the Island of Angaur (Japan), Tahiti and Makatea (French) of the Society group, and the Island of Nauru (English) of the Marshall group. According to late advices, the last mentioned island has a reserve supply of phosphate rock amounting to from 80,000,000 to 100,000,000 tons. This rock is reported to average about 85 per cent. bone phosphate of lime. Before the war Nauru and Ocean islands had a combined output of 350,000 tons per annum.

A report from Consul H. F. Withey states that phosphate is the only mineral produced in or exported from the Society Islands. It is produced and exported by one company, the Compagnie Francaise des Phosphates, a French corporation with head offices in Paris, and with a capital stock formerly of 6,000,000 francs, all French owned, except

for a relatively small amount held in Tahiti. The capital stock is now 11,000,000 francs. This concern, organized in 1908, has the exclusive mineral rights of the island of Makatea, which is about 120 miles north of Tahiti and has an area of roughly 1200 acres. Two piers about 300 meters long, a part of which length, however, is on shore, have been constructed. Mooring buoys and lighters are used by the loading vessels.

The phosphate runs about 80 per cent. bone phosphate of lime, according to the statement of the manager of the company. Before the war the annual production was from 80,000 to 90,000 metric tons. In 1919 and 1920 the production was approximately 40,000 metric tons. At present most of the phosphate from Tahiti is shipped to New Zealand.

In addition to the phosphate deposits of these islands, this mineral has recently been discovered in New Zealand, where the annual output is about 10,000 tons. Phosphate rock is also reported scattered over a wide area in South Australia. This rock ranges all the way from 50 to 70 per cent. bone phosphate of lime. The higher grades are being used for the manufacture of acid phosphate and the lower grades are finely ground for direct application to the field. Statistics showing the production from the South Sea Islands are very incomplete, but as near as can be learned at present their combined output in 1920 amounted to approximately 400,000 tons.

EUROPE

Russia.—Large deposits of phosphate occur in three regions of Russia, but prior to the war the deposits had been developed only by the Governments of Podolia and Bessarabia. These deposits are of considerable importance to European agriculture, and since they lie close to the old Austrian frontier, the Central Empires no doubt availed themselves during the war of these fields to meet, in part, the shortage of phosphate fertilizers caused by the cutting off of the supply normally imported from the United States and Africa. It has been estimated that the Russian deposits so far developed contain 80,000,000 tons of phosphate. No statistics on the production of phosphate from the Russian fields have been received since 1913.

France and Belgium.—The phosphate deposits of France and Belgium at one time largely supplied Europe's demand for phosphate fertilizers, but the annual production from these sources just prior to the war had fallen off to such an extent that the output was only a very small per cent. of the world's production. This decrease was due in part to the depletion of the deposits, but chiefly to the development of higher-grade and more easily mined deposits in other countries. Since France controls

the deposits of phosphate in Tunis and Algeria, she is drawing her main supply from those sources.

Figures showing the tonnage of phosphate rock exported and imported by France are shown in Table VIII.

TABLE VIII.—FRENCH IMPORTS AND EXPORTS OF PHOSPHATE ROCK
(In metric tons)

Year.	Imports.	Exports.
1912	903,489	22,062
1913	934,688	21,128
1914	661,429	11,219
1915	325,114	1,796
1916	285,906	1,437
1917	134,779	627
1918	228,927	36
1919	502,640	1,517

Germany.—The only phosphate deposits of importance ever controlled by Germany were those in several of her insular possessions in the Pacific Ocean. These islands have been taken over by England and Japan and therefore Germany will be obliged to depend upon other countries for her supply of this important mineral. Up to the time of the war the chief market for Florida hard-rock phosphate was in Germany. The demand for phosphatic materials in Germany, however, can be met in part by a large annual production of basic slag, a by-product of the steel industry. Up to the time of the war, Germany was a large exporter of this material. No statistics are available showing the production or consumption of phosphate or phosphatic slag in Germany during the past few years, but a recent report[1] states that in 1918 and 1919 that country produced 220,000 tons of phosphoric acid.

England.—While phosphate in the form of coprolites has been found in various parts of the British Isles, the deposits have not been of sufficient importance to meet the demand of that country for phosphatic fertilizer. England, however, controls the more important phosphate deposits of Egypt, and those of exceptional richness and value in several islands in the Pacific Ocean. England also has a large annual output of basic slag

TABLE IX.—IMPORTATIONS OF PHOSPHATIC MATERIALS TO ENGLAND
(Metric tons)

Material.	1915.	1916.	1917.	1918.	1919.
Basic slag	.....	.....	.....	100	1,724
Guano	(a) 27,159	(a) 21,991	(a) 2,643	.....	103
Phosphate rock	(a)380,651	(a)338,721	(a)281,056	(a)472,205	357,463
Total	407,810	360,712	283,699	472,305	359,290

(a) Includes Ireland.

[1] *Chem. Met. Eng.*, **21**, 431 (1919).

containing from 14 to 18 per cent. of phosphoric acid. The imports and exports of fertilizers by England for the past four years are shown in Tables IX and X.

TABLE X.—EXPORTATIONS OF PHOSPHATIC MATERIALS FROM ENGLAND
(Metric tons.)

Material.	1915.	1916.	1917.	1918.	1919.
Superphosphate	(a) 69,838	(a)14,760	(a)3,284	2,588	4,091
Phosphate rock					
Basic slag	(a)119,373	(a)39,248	(a)1,854	1,082	13,919
Total	189,211	54,008	5,138	3,670	18,010

(a) Includes Ireland.

Spain.—Only a few deposits of phosphate rock have been so far discovered in Spain, and these are of such a low grade that it no longer pays to mine them. As a neutral country, Spain prospered very materially by the late war, and with this prosperity has come an increased demand for phosphate fertilizers. Most of her supply of crude phosphates is obtained from the Algerian and Tunisian deposits, though a considerable tonnage of Florida phosphate is also imported. No statistics are yet available showing the Spanish imports of fertilizer materials in 1920.

TABLE XI.—IMPORTS TO SPAIN (a)
(In metric tons)

Material.	1915.	1916.	1917.	1918.	1919.
Phosphate rock	212,085	288,328	(b)126,266	115,028	(d)94,516
Basic slag					
Superphosphate	(c)63,013	(c)23,115	(c)12,106	11	(d) 3,494
Guano	946	1,281	2,398	988	(d) 1,835

(a) Figures obtained from Le Movement Int. des Engrais Chimiques, Rome. (b) January to October. (c) Includes basic slag. (d) First 11 months.

ASIA

Japan.—Nothing has recently been heard regarding the deposits of phosphate discovered on Rasa Island, Japan. At first these deposits were reported to be very extensive and of an excellent grade, but later reports stated that the rock was too high in iron and alumina to be successfully manufactured into acid phosphate.

Japan has fallen heir, however, to the island of Angaur in the Pacific Ocean, and is actively engaged in mining and shipping high-grade rock from those deposits. Considerable phosphate rock is also imported into Japan from Egypt and a small tonnage from the United States.

The imports of phosphate rock to Japan, as far as they are available, are given in Table XII.

TABLE XII.—IMPORTS OF PHOSPHATE ROCK TO JAPAN

Country.	1913.	1914. (a)	1915.	1916.	1917.	1918.	1919.
England	21,990	(b)					
France							
United States	38,740	54,063	135,800	99,702	155,446	89,572	191,537
Egypt	29,700	68,157					
Other countries	238,150	144,702					

(a) From January to September, 1914. (b) Included in figures for other countries.

TECHNOLOGY

The gradual depletion of the better grades of phosphate rock in our Eastern deposits, coupled with the increased cost of handling and transportation, has made it evident that sooner or later we must obtain better recoveries of phosphate in mining operations and produce more concentrated materials for fertilizer purposes. Increased attention therefore is being directed toward more efficient mining methods and to processes which have for their object the production of concentrated phosphatic materials or compounds.

Pyrolytic Production of Phosphoric Acid.[1]—Considerable progress has been made during the year on the production of phosphoric acid by the furnace process, using fuel as a heating agent in lieu of the electric arc. Contrary to general opinion, it has been found perfectly feasible to obtain practically complete volatilization of phosphoric acid from mixtures of phosphate rock, sand and coke at the temperatures attained and under the conditions obtained in the fuel-fed furnace. Results obtained in experiments conducted over a period of 20 hr. or more on briquetted charges of "mine-run" phosphates have indicated very strongly that this method is commercially feasible and may eventually supplant the old process so long in use for producing soluble phosphates by treatment with sulphuric acid. The results obtained have opened up enormous possibilities of utilizing low-grade deposits of phosphate rock formerly considered of little or no commercial value, and this process promises also to eliminate to a large extent the great losses entailed in the present method of preparing high-grade phosphate rock for the market.

Process of Carlton C. James.[2]—With the idea of obtaining an alkaline phosphatic fertilizer soluble in soil waters and one which will neutralize any soil acidity and promote bacterial activity, James proposes to mix ordinary acid phosphate with a reverting agent, such as lime or limestone, delivering the mixture to a container and allowing the reactions to take place until the product is alkaline to litmus. This process is not particularly new, as it has been suggested and practiced a number of

[1] *Chem. Met. Eng.*, **23**, 1057 (1920).
[2] U. S. Patent No. 1,348,495 (1920).

times. Since the product contains little or no water-soluble phosphoric acid it is not feasible to obtain anything like the equable distribution of phosphate that is practicable with the same quantity of acid phosphate.

Process of J. N. Carothers.[1]—With a view to producing a fertilizer containing both available nitrogen and phosphoric acid, Carothers has suggested the treatment of phosphate rock with concentrated nitric acid (40 per cent. HNO_3) and then adding to this resultant mass a sufficient quantity of calcium cyanamid to revert the monocalcium phosphate formed to dicalcium phosphate. The inventor claims that the deliquescent nature of the nitrate of lime produced by treating phosphate rock with nitric acid is destroyed by the addition of the cyanamid. It is said that this change brought about in the nitrate of lime is physical rather than chemical, but the resultant product is a relatively dry pulverulent material which can be readily handled.

Process of Making Hydrogen-containing Alkali-metal Phosphates and a Salt Produced Therein.[2]—This process has for its object the production of a concentrated fertilizer material containing two or more fertilizer ingredients. The process consists in first treating phosphate rock with sufficient sulphuric or hydrochloric acid to form dicalcium phosphate ($CaHPO_4$). This product is then treated with potassium or ammonium sulphate, or both, forming soluble phosphates of alkali metals and insoluble sulphate of lime. The digestion of the dicalcium phosphate with the sulphates of alkali metals is usually carried out at high pressure and at a temperature of 120 to 140° C. When the reaction is complete the resultant mass is lixiviated with water, filtered, and the filtrate evaporated until the salts of phosphoric acid crystallize.

Hoffmann's Processes.[3]—These processes, which have been assigned to the Virginia-Carolina Chemical Co., also have for their object the production of relatively concentrated fertilizer materials containing available phosphoric acid and nitrogen. Briefly, the method consists in treating calcium cyanamid with either concentrated or dilute phosphoric acid with the formation of mono- or dicalcium phosphate and phosphates of ammonia. The reactions which the inventor claims take place may be presented thus:

$$CaCN_2 + CaO + 6\,H_3PO_4 + 3H_2O = 2CaH_4(PO_4)_2 + 2H_2O + 2\,NH_4H_2PO_4 + CO_2$$

Where dilute phosphoric acid is used the dicalcium phosphate or less soluble compound is formed and the soluble ammonium phosphate may be separated from it if desired by filtration. Since calcium cyanamid

[1] U. S. Patent No. 1,350,591 (1920).
[2] U. S. Patent No. 1,357,120 (1920).
[3] U. S. Patent Nos. 1,360,401 and 1,360, 402 (1920).

can only be used in mixed fertilizers to a limited extent and because of its nature offers certain objectionable features, this process, if practical, would seem to obviate a good deal of trouble experienced in using this synthetic nitrogenous compound.

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PLATINUM

By George F. Kunz

The platinum industry is gradually emerging from the chaotic condition into which it was thrown by the cutting off of the Russian supplies, and by the coincident intense demand for the metal in connection with the manufacturing of war materials. The Russian sources, both new and old, are slowly coming to the front again, and the increased production in Colombia, at first greatly stimulated by the cessation of Russian shipments, has been rendered more stable and promising by the organization of powerful companies, financed in the United States. At the same time some much-needed laws have been enacted to insure the purity of articles purporting to be made of platinum or of the other platinum metals. Although the special war demand has largely ceased, its place is taken by a revival of the demand for jewelry and dental uses, while the needs of the chemical industries are constant and permanent. As a result of these various factors the price of platinum, although it has fallen decidedly from the high mark of 1919 and the first half of 1920, maintains itself at from $70 to $75 an oz., and it does not seem likely to fall much beneath these figures. Iridium, however, because so much rarer, and because of its necessary employment to give hardness and stability to pure platinum, continues to command a much higher price per ounce than the latter metal. Taken in its entirety, the present aspect and the future prospects of the platinum industry are such as to encourage every effort to open up new sources of production and to develop more extensively the older sources.

The Platinum Stamping Law of New York State, which went into effect Sept. 1, 1920, does not require that a manufacturer shall stamp any article made of platinum, but merely provides a standard for stamping in case the dealer wishes to set such a mark on such of his wares as contain platinum. Nevertheless this law provides an effective guarantee for a purchaser against any misrepresentation on the part of the dealer, for if an article is made of platinum, in combination with the metals resembling platinum, and a dealer stamps, bills, or marks this article as being of platinum, it must conform to the standard of 925 thousandths fine, or else the law has been violated. Moreover, the dealer may not take refuge in his ignorance of the lack of conformity to the standard, for he is regarded as responsible for the genuineness of the article he sells, that is to say, for its conformity to the stamp or mark it bears, or to the

designation under which he sells it. The term "platinum," however, includes all metals of the platinum group, the totality of such metals being included in the 925 thousandths required by the law.

AVERAGE MONTHLY PRICES OF PLATINUM AT NEW YORK
(In dollars per troy ounce)

	1912.	1913.	1914.	1915.	1916.	1917.	1918.	1919.	1920.
January.....	46.00	45.50	43.38	41.10	90.05	87.83	105.92	104.85	154.23
February.....	45.63	45.50	43.50	40.00	90.00	103.75	107.68	100.43	151.59
March.....	45.50	45.50	43.50	39.50	90.75	104.33	108.00	99.20	138.56
April.....	45.50	45.50	43.50	38.63	83.10	103.77	108.00	99.85	127.04
May.....	45.50	45.50	43.50	38.50	80.50	105.00	106.27	102.60	97.50
June.....	45.50	45.50	43.50	38.00	78.13	104.75	105.00	105.80	85.19
July.....	45.50	45.50	43.50	38.00	63.60	103.88	105.00	105.90	83.94
August.....	45.50	44.90	50.20	39.25	62.56	104.55	105.00	107.60	111.44
September....	45.50	43.96	50.00	50.00	84.25	104.13	105.00	128.70	115.20
October.....	45.50	44.00	49.50	54.50	89.75	104.00	105.00	132.21	101.70
November....	45.50	43.70	45.45	62.63	101.25	104.52	105.00	136.74	84.75
December.....	45.50	43.45	42.19	85.50	86.87	104.38	105.54	151.35	79.62
Year.....	45.55	44.88	45.14	47.13	83.40	102.82	105.95	114.61	110.90

The decision of the Board of United States General Appraisers, rendered Dec. 30, 1920, was believed to settle definitely the status of irido-platinum sheets as imports, and to affirm the claim that they share in the provisions of paragraph 578 of the tariff act of 1913, exempting "platinum, unmanufactured, or in ingots, bars, plates, sheets, wire, sponge or scrap," and are not subject to the 50-per cent. *ad valorem* duty imposed in paragraph 167 on "articles or wares, composed wholly or in part of platinum." The fact that platinum needs the added hardness imparted by an admixture of iridium in order to render it satisfactorily available for industrial or artistic uses, is too well known to require notice here.

PLATINUM MARKET FLUCTUATIONS, 1910 TO APRIL, 1921

1910.—The platinum price fluctuated from $28.00 in January to $39.25 per troy oz. in October.

1911.—February $41.00 per troy oz. to $45.00 in August.

1912.—$45.00 per troy oz.

1913.—$46.00 per troy oz. in January.

1914.—$48.00 per troy oz. in September down to $43.00 in December.

1915.—$40.00 per troy oz. in March to $50.00 in September.

1916.—
$ 90.00 on Jan. 11th
85.00 on Jan. 18th
88.00 on Feb. 25th
85.00 on Apr. 24th
80.00 on May 15th
75.00 on June 12th
70.00 on July 5th
65.00 on July 10th
60.00 on July 17th
$ 65.00 on Aug. 21st
80.00 on Aug. 28th
85.00 on Sept. 11th
90.00 on Sept. 21st
95.00 on Oct. 30th
100.00 on Nov. 1st
105.00 on Nov. 10th
110.00 on Dec. 11th

1917.—	$95.00 on Jan. 26th	$90.00 on Dec. 18th	
	100.00 on Jan. 29th		
	105.00 on Feb. 5th		
1918.—	108.00 on Jan. 16th		
1919.—	$105.00 on Jan. 2nd	$115.00 on Sept. 10th	
	100.00 on Feb. 10th	130.00 on Sept. 12th	
	105.00 on July 14th	135.00 on Nov. 3rd	
	110.00 on Aug. 22nd	150.00 on Dec. 1st	
1920.—	$155.00 on Jan. 12th	$ 85.00 on June 10th	
	142.00 on Mar. 2nd	105.00 on Aug. 2nd	
	133.00 on April 4th	115.00 on Aug. 14th	
	125.00 on April 27th	105.00 on Oct. 5th	
	115.00 on May 4th	100.00 on Oct. 15th	
	95.00 on May 14th	85.00 on Nov. 11th	
1921.—	$80.00 on Jan. 5th		
	70.00 on Jan. 18th		
	75.00 on March 14th		

The great rise in the value of platinum has caused an urgent demand for it in a quarter whence this demand is not desired. We mean from that section of the community whose members live by thieving. Not long since, a New Jersey manufacturing concern reported that $75,000 of the precious metal had been stolen; a good portion of this has been fortunately recovered, it is said. It is not stated, however, that equal good luck has been enjoyed by the Department of Agricultural Chemistry at the University of Missouri, from whose vault had been stolen the entire stock of platinum crucibles, weighing in the aggregate as much as 2500 grams, worth nearly $6250 at present rates. Other institutions also are said to have been despoiled in this way. Indeed, in one instance an entire university laboratory was burned down to hide the theft of platinum. Chemical laboratories and mineralogical museums seem to be the greatest sufferers, unhappily in many cases through those employed in them.

It has been suggested by Dr. W. F. Hillebrand, Chief Chemist of the Bureau of Standards, that a stop might be put to the platinum thefts if a proper system of platinum registration should be required. As the only really effective legislation on this matter ought to have a national scope, and be enacted by Congress, it would be necessary to have it based upon conditions affecting interstate commerce, so as to bring it within the sphere of congressional prerogative, unless, as has also been proposed, the matter could be brought under the control of the internal revenue department, by levying a very small sales tax upon platinum. This tax need not exceed one-tenth of 1 per cent., just enough to pay for the expense of the registering agencies. The importance of some such

legislation is emphasized by the fact that on one occasion more than $10,000 worth of platinum was stolen from the Bureau of Standards, and the University of Michigan and the University of Wisconsin have also been sufferers in this way. A still heavier loss, of $40,000 worth of the metal, was inflicted upon a manufacturer in the neighborhood of New York City.[1] It is also reported that there were taken from the U. S. Smelting, Refining and Mining Co., of Midvale, Utah, on Feb. 20, 1920, apparatus amounting to 5 oz. troy, while from the chemical laboratory of Wells College, between Feb. 12 and 15, 1920, thieves made off with a number of platinum articles weighing about 16 troy oz. With platinum at $70 or $80 an ounce this constitutes a serious loss.

An adequate idea of the value of recent platinum thefts is given by two trials before the Federal Court at Nashville, Tenn., on Apr. 7, 1921. In the first case the jury found a verdict of guilty against the accused, on a charge of embezzling $26,000 worth of platinum from the Government, while he was employed as chief chemist at the Old Hickory powder plant at Nashville. The same offender was charged with having embezzled $188,200 worth of platinum, in addition to the $26,000 involved in the first trial, and was found guilty on this charge as well.

A novelty in the art of thieving platinum is reported from France. On the towers of the famous Cathedral of Notre-Dame in Paris, the lightning rods have been tipped with platinum as a protection against heaven's artillery. This circumstance induced a gang of thieves to cut their way through a panel of the massive oak door barring the way to the tower stairway, and to perform the same operation on three other successive doors. Once on the platform of the towers, they sawed through the copper lightning rods, and dismounted them so that they were able to take off the platinum balls with which they were tipped. These weighed about half a kilogram, or 16 oz., worth at least $1000, or about 13,000 francs at present exchange. Another similar case is the reported stealing of platinum lightning-rod tips from three of the French forts on the Italian frontier.

United States Platinum Production and Imports in 1920[2]

Estimates of the production of crude placer platinum in the United States in 1920 give Alaska, 27 oz. troy; California, 656 oz.; Oregon, 23 oz.; and Washington, 8 oz.; total, 714 oz. troy.

Refiners reported a production of 41,544 troy oz. of new platinum metals in 1920, of which 36,015 oz. was platinum, 418 oz. iridium, 409 oz. osmiridium, 4,309 oz. palladium, and 393 oz. of the minor platinum-group

[1] *Chem. Met. Eng.*, July 21, 1920.
[2] U. S. Geol. Surv.

metals, including rhodium and osmium. This represents a decrease of 3,565 oz., as compared with the production in 1919.

There was also produced 57,710 oz. of secondary platinum metals in 1920, of which 51,255 oz. was platinum, 3,355 oz. iridium, and 3,100 oz. palladium. This represents a decrease of 3,806 oz., as compared with the production in 1919.

The platinum metals imported for consumption in 1920 included 80,955 oz. of crude platinum and unmanufactured ingots, bars, sheets, etc., of which approximately 58,009 oz. is believed to be refined metal; 4,718 oz. of iridium; 4,473 oz. of osmiridium; 6,944 oz. of palladium; 2,675 oz. of the minor metals; and 781 oz. of manufactured platinum ware.

The consumption of platinum metals in the United States in 1920 was 141,041 oz., of which the jewelers took 57 per cent., the electrical industry 19 per cent., the dental industry 11 per cent., the chemical industry 10 per cent., and miscellaneous uses 3 per cent.

The stocks of platinum metals at the end of 1920 amounted to 67,508 oz., which is an increase of 55 per cent. as compared with the stocks at the end of 1919.

The following table shows the amounts of new platinum and other metals of the platinum group that were recovered by refiners from gold bullion, nickel and copper in the United States in the years 1918–1920.[1]

Year.	Platinum.		Iridium, Troy Oz.	Osmiridium, Troy Oz.	Palladium, Troy Oz.	Rhodium, Troy Oz.
	Troy Oz.	Grams.				
1915	6,495	202,017	274	335	1,541	.....
1916	24,518	762,596	370	315	2,885	.....
1917	33,009	1,026,695	210	833	4,779	.....
1918	54,399	1,691,999	465	539	4,024	326
1919	40,220	1,250,983	401	402	3,807	279
1920	36,015	1,120,175	418	409	4,309	393(a)

(a) Includes osmium.

By secondary metals are meant those metals which are recovered by refining scrap metals, sweepings, and all waste products of manufacture that contain the platinum metals. The quantities reported undoubtedly cover some duplication, as platinum metals may be recovered from scrap several times in a year. Yet it is believed that information on this subject is of great importance, for the yearly output of new refined metals is not sufficient to meet the demand, which, therefore, must be supplied by reworking waste material of all kinds.[2]

[1] J. M. Hill, *Min. Res. of the U. S.*
[2] J. M. Hill, *Min. Res. of U. S.*, 1919.

STATISTICS OF PLATINUM IN THE UNITED STATES

Year.	Production. (a)		Imports.			Total.
			Unmanufactured. (b)		Manufactured.	
	Troy Oz.	Value.	Troy Oz.	Value.	Value.	Value.
1903	110	$2,080	114,521	$1,921,772	$135,889	$2,059,741
1904	200	4,160	103,802	1,812,242	105,636	1,922,038
1905	318	5,320	104,196	1,985,107	188,156	2,178,583
1906	1,439	45,189	137,556	3,601,021	187,639	3,833,849
1907	357	10,589	74,208	2,509,926	175,651	2,696,166
1908	750	14,350	50,768	1,096,615	134,119	1,245,084
1909	638	15,950	118,851	2,557,574	410,997	2,984,521
1910	773	25,277	120,478	3,320,699	333,965	3,679,941
1911	940	40,890	122,390	4,722,752	135,842	4,899,484
1912	1,005	45,778	104,683	4,334,488	159,995	4,540,261
1913	1,034	46,530	117,947	4,938,706	105,553	5,090,789
1914	3,430	154,350	72,267	2,934,580	39,143	3,128,073
1915	6,495	322,347	61,437	2,340,476	71,532	2,734,355
1916	24,518	2,044,801	53,484	3,138,396	18,923	5,202,120
1917	33,009	3,393,985	30,316	2,414,773	382	5,809,140
1918	54,399	5,763,574	54,962	4,949,755	14,225	10,727,554
1919	40,220	4,609,614	54,550	5,229,309	17,213	9,856,136
1920	36,015	3,994,064	80,955	8,474,499	94,408	12,562,971

(a) Statistics of the U. S. Geol. Surv. Recovered by refiners. (b) Includes ingots, bars, plates, etc.

SECONDARY PLATINUM AND ALLIED METALS SOLD (a)
(Troy ounces)

Year.	Platinum.	Iridium.	Palladium.
1915	42,149	863	958
1916	45,156	1,535	1,284
1917	59,007	9,832	3,347
1918	40,378	3,410	1,795
1919	54,545	3,504	3,467
1920	51,255	3,355	3,100

(a) U. S. Geol. Surv.

IMPORTS OF THE ALLIED PLATINUM METALS INTO THE UNITED STATES FOR THE YEARS 1918–1920

1918.

Iridium	1,106	34,400	$126,282	$114.18	$3.67
Osmiridium	427	13,281	46,321	108.48	3.49
Osmium	.....	.....	.....	.....	.....
Palladium	240	7,465	36,853	153.55	4.93

1919.

Iridium	5,808	180,646	$975,174	$168.24	$5.40
Osmiridium	1,374	42,736	112,403	81.81	2.63
Osmium	2,339	72,750	132,097	56.47	1.82
Palladium	3,739	116,294	250,777	67.07	2.08
Rhodium	222	6,905	30,474	137.27	4.43

1920.

	Troy Oz.	Grams.	Value.	Aver. per Oz.	Aver. per Gram.
Iridium	4,718	146,744	$726,502	$153.99	$4.95
Osmiridium	4,473	139,124	450,241	100.66	3.24
Osmium	593	18,544	39,517	66.64	2.13
Palladium	6,944	215,979	612,248	88.17	2.83
Rhodium	2,053	63,854	217,385	105.88	3.24
Ruthenium	29	902	2,640	91.03	2.93

Alaska.—It is reported that the gold placers of the Chistochina district (State Creek), in the southeastern portion of Seward Peninsula, and also in some other districts, continued to produce small quantities of platinum in 1920.[1]

The Salt Chuck mine (formerly the Goodroo mine), situated between Lake Ellen and the source of Salt Chuck creek, at the head of Kasaan Bay, Prince of Wales Island, Alaska, was originally operated for its low-grade copper deposit, but subsequently the platinum and palladium content were found to be more valuable than the copper, so that it is now termed a "palladium-copper mine." Work has been carried on here continuously since 1917, some 16 miners being employed in 1919. The deposit occurs in an area of course-grained intrusive pyroxenite rock, of the kind which invades the paleozoic sedimentary rocks of Kasaan Peninsula at many localities. The ore minerals consist of sulphides in grains and small patches in the pyroxenite. Bornite is the chief copper mineral, but a little chalcopyrite occurs locally. Both chalcocite and covellite are present, as alteration products of the bornite and chalcopyrite. Besides palladium, a little gold, silver and platinum is recovered. As partial tests have shown the presence of somewhat more than 3 oz. of palladium to the ton of concentrate, and as a ton of concentrate represents about 28 tons of ore, there would be a palladium content of a little over one-tenth of an ounce to the ton of ore. The proportion of the palladium to the small amount of platinum in these deposits is estimated at about 50 to 1. Each ton of ore is figured to contain about 28.5 lb. of copper.[2] At 12 or 13 cts. a lb. the copper would only be worth from $3.40 to $3.70, while the 0.1 oz. of palladium might be valued at $12 or $13.

The company organized to exploit the platinum and palladium deposits of Kasaan Bay, Alaska, has a capitalization of 150,000 shares issued at $10 each. The company owns 29 full mining claims and 16 partial ones, and the statement is made that out of one-tenth part of a claim, opened up to a depth of 150 ft., ore worth $400,000 has been secured. The material is sold to the smelting works in Irvington, N. J. In all, it is asserted that 200,000 tons of ore has been extracted, the net value of this being about $1,000,000. Should all expectations be realized, this Alaskan field would make quite a notable contribution to the world's production of platinum.

Platinum Metals in Foreign Countries

Australia.—In Tasmania, while platinum deposits have not yet been discovered, although a little of the metal has been secured in the refining

[1] U. S. Geol. Surv.
[2] J. B. Mertie, Jr., "The Salt Chuck Palladium-copper Mine," *Eng. Min. Jour.*, July 3, 1920.

of blister copper, osmiridium deposits of some importance have been found on the Savage River (Bald Hills) and Wilson River, in the northwestern part of the island. Here it appears in areas of serpentine, in the form of nuggets and fine grains in alluvial deposits, with magnetite and chromite, and close to the boundary of sedimentary rocks and the intrusive serpentine. Regarding these osmiridium deposits, Mr. A. I. Reid, Assistant Government Geologist of Tasmania, gives the following information:[1]

"The occurrence of bronzite, enstatite, and olivine in peridotites, pyroxenites, and gabbros—or in serpentine resulting from the decomposition of these rocks—is considered to be favorable for the presence of osmiridium, while monoclinic pyroxenes, such as augite and diallage, appear to be limited to rocks barren of osmiridium. The deposits containing osmiridium are almost exclusively confined to differentiation streaks, or "schlieren," in structural planes developed in the rock, and not only is it possible to distinguish the osmiridium-bearing serpentines from those that are barren, but the precise location of the deposits in these rocks can be fixed without difficulty. Other interesting features are the presence of chrome spinel in the serpentines and the high percentage of alumina in bronzite."

The osmiridium output of Tasmania has fluctuated considerably since 1910, when the local government began to take official cognizance of it, and when 120 oz. of the precious metal was produced. By 1912, the output had risen to 778 oz., and in 1913 it was 1261 oz. Although mining was partially checked in 1914 by the outbreak of the war, 1018 oz. were recorded for that year. Then came the poor years 1915, with 247 oz., 1916, with but 222 oz., and 1917, with 332 oz. In 1918 the demand for the metal for war munitions sent the production up to 1606 oz., and in 1919 the output was 1669½ oz. A curious circumstance is reported concerning the osmiridium deposit on the brow of Bald Head, in the Savage River district, facing Nineteen Mile Creek, for the official bulletin states that here a miner has been quarrying solid serpentine rock for over 6 years, and has secured high-grade osmiridium by crushing this rock. The assertion is made that he is the first and only miner in the world to find the metal actually occurring in the solid rock.[2]

The 1920 output was the largest yet recorded, amounting to 2009 oz., valued at £77,114.

Regarding the sources of the platinum and associate minerals found in the black sands at certain localities of Australia, such as Ballina, near the mouth of the Richmond River, Evan's Head further to the south, and Currumbin, near the mouth of the Twedd River, northward of the locality just mentioned, Mr. Dunstan, Chief Government Geologist, admits that in the case of the associated minerals the source is prob-

[1] Cited By B. Dunstan in *Queens. Govt. Min. Jour.*, Jan., 1921, p. 20.
[2] *Min. Sci. Press*, Aug. 14, 1920.

lematical, but he considers that the platinum and osmiridium were probably derived from the serpentine area, which forms in part the western edge of the Clarence coal measures. He further states:[1]

"Possibly in former times the platinum and other minerals, each from their individual source, were accumulated in the sediment forming the Clarence series of rocks, and which natural agencies are now redistributing in the coastal sands. Along this coast the disposition of sand is northerly from the rivers bringing the material down from the high lands, and this suggests the idea that the sources of the minerals are always south of the beach deposits in which they happen to occur. Some of the Currumbin sands, indeed, have been found to contain chromite, which rather indicates the serpentine to be the source of some of the minerals contained in them."

"At Ballina and Evan's Head the platinum is the predominating mineral in the sands, with gold in small quantities, while at Currumbin, further north—and further from its source—the platinum is only in traces, with the gold in greater quantities. In California and Oregon, platinum is found in the beach sands of the Pacific Coast, and evidently under similar conditions to those at Ballina and Currumbin.

Canada.—While the Canadian production of platinum metals has increased somewhat in recent years, it is still far below what might be expected. The International Nickel Co. of Canada, in the refinery at Port Colborne, Ont., reports a recovery in 1920 of 88.7 oz. of platinum in an impure state, besides 173.8 oz. of palladium, and 19.6 oz. of rhodium, ruthenium, osmium and iridium. At the New Jersey refining plant of this company, where the recoveries are believed to be mainly if not exclusively from Sudbury, Ont., matte, there were secured 488.9 oz. of platinum; 739.2 oz. of palladium; 309.3 oz. of rhodium, and 102.4 oz. distributed among the platinum metals, osmium, iridium and ruthenium. In the refinery of the British America Nickel Corporation at Deschenes, Que., the residues from the refining operations are being stored for future treatment.

There should be added to the quantities mentioned a platinum production of 17 crude oz. in 1920 from alluvial sands, even less than the 25 oz. recovered from the sands in 1919. The Canadian exports of platinum in 1920 were 473 oz. of ore, concentrates, etc., valued at $53,956, and 317 oz. of "scrap" platinum, valued at $31,784.[2]

It is asserted that platinum deposits of great value can be derived from the Fraser River, British Columbia, and from three of its tributaries, the Quesnal, Mellon and Cottonwood rivers. The statement is made that for a stretch of 250 miles along the Fraser, and for about 150 miles

[1] *Queens. Govt. Min. Jour.*, Jan., 1921, p. 20.
[2] Prelim. Rept. Min. Prod. of Canada, 1920, Can. Dept. of Mines.

on each of the three tributaries, as much as 75 per cent. of the black sands can be profitably worked. Tests are said to show that the sands yield from 8 to 40 lb. of concentrates per cubic yard. The value of these concentrates varies greatly, ranging from $40 up to $1200 per ton. Besides platinum, they contain iridium and osmium; there are also smaller quantities of the other platinum metals, palladium, ruthenium and rhodium. The Cariboo Gold and Platinum Reduction Co. has established a plant and was prepared to begin active operations in the spring of 1921. Should the expectations be realized, British Colombia should furnish a considerable amount of platinum and of the other platinum metals.

STATISTICS OF PLATINUM IN CANADA (a)

Year.	Production, Crude.		Exports.		Imports, Value.	
	Troy Oz.	Value.	Troy Oz.	Value.	Wire, Bars, Etc.	Crucibles, Retorts, Etc.
1909	.....	.....	466	$2,118	$61,441	$13,049
1910	.....	.....	2,254	62,776	100,185	12,874
1911	.....	.....	39	1,961	170,944	4,549
1912	.....	.....	92	3,821	224,216	7,974
1913	18	$489	158	7,929	141,117	4,557
1914	.....	.....	43	2,161	69,736	9,937
1915	23	1,063	236	11,052	65,040	19,047
1916	15	600	532	41,945	68,633	19,910
1917	57	3,823	331	29,599	107,409	6,870
1918	39	2,560	197	20,892	25,004	6,136
1919	25	2,150	671	62,629	144,989	15,896
1920	17	....	790	85,740	(b)82,647	(b)17,483

(a) Annual Rept. Min. Prod. of Canada. (b) Dept. of Trade and Commerce, year ending Mar. 31, 1921.

Chile.—The black sands on the coast of the Island Chiloe, which belongs to Chile, have lately been proved to hold a considerable quantity of platinum in addition to the gold they contain. The deposits are due to the erosive action of the waves, and the eroded material has been concentrated by the movement of the sea. The amounts of black sands vary notably, constituting as much as 50 per cent. of the deposit at some places, while at others there is but a trace. The concentrates are usually secured near to the present high-water mark. Platinum is found in appreciable quantities only from Tablacura beach and southward, the richest deposits bring those of Lavaderos beach. This is near the extreme southwestern point of the island, immediately south of the Zorras River. This beach is of inconsiderable extent, having a length of only about 25 meters at high tide, but the richest concentrates occur in a strip 25 meters wide between high and low tide. The platiniferous sand averages from 10 to 20 cm. in thickness, and lies over a false bed-rock of clay, and beneath an overburden of 50 cm. of light-gray beach sand; there is said to be a second layer of platiniferous sand beneath the bed-rock. An examination of samples taken at random indicates from 1½ to 2 gm. of platinum

per cubic meter. It occurs in thin flaky scales, and is in a free state; there is an iridium content of about 10 per cent. An attempt is being made to exploit the sands by means of a dragline operated by steam, and having a daily capacity of some 20 cubic meters. After screening, the sands are to be passed over amalgamating plates to remove the gold, and they are then to be concentrated on stationary canvas and burlap tables, to secure the platinum. The plant has been so recently installed that no data as to results are yet to be had.[1]

The island of Chiloe, where these platinum gravels have been found, is about 100 miles long and averages some 30 miles in width. It is divided from the mainland of Chiloe by the Chacao Channel, and is bounded on the east by the gulfs of Ancud and Corcovado, which constitute the northern end of the inside waterway to the Strait of Magellan. Small freight steamers, of almost 50-ton register, run between the island and Puerto Montt, the southern terminal of the Chilean Government railway. The time required for the journey from Ancud on the island to Puerto Montt is from 8 to 9 hr., and the railway trip thence to Santiago takes about 24 hr.

Colombia.—The two great platinum-bearing rivers in Colombia are the Atrato and the San Juan. Of these the former, which empties into the Gulf of Darien, is about 300 miles long, is navigable by steamers for two-thirds of its course, and discharges an immense volume of water during and immediately after the rainy season. Although the bars at the river's mouth are only from 5 to 6 ft. below the water's surface, the channel is from 750 to 1000 ft. wide, and has a depth of from 40 to 70 ft. for 100 miles; even at Quibdo, which is 220 miles inland, the river is from 8 to 20 ft. deep and 850 ft. in width. The navigable stretch for steamers reaches some 30 miles farther up, to the confluence of the San Pablo and Certigui rivers. The San Juan is not quite so long as the Atrato, but to its 245 miles should be added the length of a number of affluents, and with these we can count nearly 300 miles of water open to navigation, though only for 140 miles by steamers. It has a width of from 300 to 1200 ft., and discharges into the Pacific 50,000 cu. ft. of water per second, which is a greater volume than is discharged into the Pacific by any other of the South American rivers. Another great source of Colombian platinum is the region of the Condoto River, but this has not yet been thoroughly explored, so that nothing approaching an exact estimate can be made of its productivity.[2]

It is becoming more and more generally recognized that the $25,000,000 indemnity to be paid by the United States to Colombia will be made to contribute to the prosperity of the nation according it. For this

[1] Fritz Mella, "Black-sand Deposits of the Island of Chiloe," *Eng. Min. Jour.*, Mar. 19, 1921.
[2] J. Ovalle, "Platinum in Colombia," *Eng. Min. Jour.*, Nov. 6, 1920.

money, as well as loans for which it will serve as a basis, will be expended in developing the great natural resources of Colombia, not the least of which is its platinum, and the greater the production of this extremely useful metal, the greater will be the quantity available for export to the United States. This will supplement the efforts already being successfully made by capitalists of the United States to increase the platinum output from Colombia's alluvial deposits.

UNITED STATES IMPORTS OF PLATINUM FROM COLOMBIA
(In troy ounces)

Year. (a)	Quantity.	Value.
1910	1,600	$31,383
1911	5,503	147,820
1912	6,627	219,128
1913	10,461	363,731
1914	12,387	398,657
1915	13,601	470,938
1916	25,588	1,473,553
1917	21,278	1,536,422
1918	27,030	2,241,744
1918(b)	30,543	2,630,614
1919(b)	26,046	2,303,211
1920(b)	.....	.....

(a) Fiscal year ending June 30. (b) Calendar years.

Germany.—In relation to certain reported occurrences of platinum in the Siegerland and Sauerland districts of Germany, F. Beyschlag states, in the "Zeitschrift für praktische Geologie," that although exaggerated expectations exist as to the importance of these finds, based on inadequate and unreliable research methods, the presence of small quantities of the metal appears to be well established. The platinum occurs in an irregular and hitherto unconcentrated form, but the writer thinks there is good reason to hope that in time secondary concentrations will be met with, or that improved methods will be devised for utilizing the irregularly distributed material.[1]

In the long list of raw materials needed in Germany last September, and submitted by the German Government to the Reparations Committee, appear 150 kilos, or 4822 troy oz., of platinum. A part of the sum due for the great amount of foods and raw materials specified in the German request is to be paid for out of the initial 20,000,000,000 marks (nearly $5,000,000,000) constituting the first installment of the immense indemnity imposed upon Germany. This platinum would be worth about $350,000 and perhaps more than that.

Russia.—A thoroughly trustworthy record of the early Russian production of platinum has been preserved for us. In the 16-year period

[1] *Min. Jour.*, Nov. 6, 1920.

running from 1823 to the end of 1839, the official Russian returns give the platinum output as follows:[1]

	Poods.	Pfunds.	Zolotniks.	Doli.
From Crown Mines	29	..	83	82
From Nizhni-Tagilsk	1,216	29	91	36
From other private mines	13	13	65	10
Totals	1,259	4	48	32

Turned into grams and troy ounces this gives:

	Grams.	Troy Ounces.
From Crown mines	475,392	15,282
From Nizhni-Tagilsk	19,930,924	640,722
From other private mines	218,547	7,026
Totals	20,624,863	663,030

At the present ruling price of platinum this would have a value of about $40,000,000, estimating that the grade was 83 per cent.

From 1887 to 1913, Russia is said to have produced 7837 poods' weight of platinum (4,127,318 troy oz.) and to have exported platinum weighing 6428 poods, or 3,385,275 troy oz. This export was divided among the principal importing countries in the following proportion: France, 70.09 per cent.; Germany, 29.13 per cent.; England, 0.78 per cent. Of course a good part of the refined platinum was in turn re-exported by France and Germany, mainly by France. As to the amount of platinum still remaining in the explored mines we are told that it can be put at about 7000 poods, or nearly 3,700,000 troy oz.[2]

From time to time a little information as to the present Russian platinum production leaks out. Thus the London *Financial World* reported not long since that about 400 poods' weight of the metal had been mined in the Urals in 1920. This would mean a production of 210,646 troy oz., which, under existing circumstances seems hardly possible. It is also stated that in the refining factory in Moscow there was secured 54 poods, or 28,436 oz. of platinum, and 3000 poods, or nearly 1,600,000 oz. of silver.

Official figures furnished by the Bureau of Foreign and Domestic Commerce, on Nov. 15, 1919, give these statistics regarding the production of platinum in Russia during the years 1901 to 1917 inclusive, and for a part of 1918. (The weights in poods are here reduced to troy ounces and kilograms.)

[1] Schriften der Russisch-Kaiserlichen Gesellschaft für die gesammte Mineralogie, Vol. I, Pt. I, St. Petersburg, 1842.
[2] From Dobrokhotov's "The Urals."

Year.	Weight in Poods.	Weight in Troy Ounces.	Weight in Kilograms.
1901	389	204,965	6374.21
1902	375	197,392	6138.89
1903	367	193,279	6010.98
1904	306	161,153	5011.86
1905	320	168,526	5141.16
1906	353	175,906	5470.68
1907	329	173,266	5388.57
1908	299	157,467	4897.22
1909	313	164,849	5126.52
1910	335	176,426	5486.85
1911	352	185,379	5765.29
1912	337	177,479	5519.60
1913	299	157,467	4897.22
1914	298	156,960	4880.83
1915	206	108,489	3374.01
1916	150	78,997	2456.81
1917	187	98,483	3062.72
1918 (to July 1)	25	13,166	409.46

These figures are from the Isvestya Gornavo Otdela for August-September, 1918.

Concerning the reported discovery of new platinum deposits in the Petshora region of the Urals, B. Simmerbach, of Wiesbaden, Germany, in an article contributed to the publication *Edelerden und-Erze*, writes that, from his personal knowledge of the district, there can be no doubt that platinum and gold are to be found in the northern part of the Urals, notably in the Pakoi region, as well as in the Petshora district, and it is his conviction that an adequate survey will reveal the existence of very valuable platinum ores here.[1]

Osmiridium in Russia has been obtained exclusively in the Urals, from the Miass district of the Orenburg Government, and in the North Ekaterinburg district of the Perm Government, although in the last-mentioned district the mining of this metal has been abandoned. The annual production had decreased rapidly within the 12 years from 1902 to 1914, with a very slight recovery after 1912. In 1902 about 231¼ troy oz. was produced, the production falling by rapid stages to a little over 2½ oz. in 1912. In 1913 about 8¼ oz. was obtained and in 1914 a trifle over 10½ oz. The total for the twelve years was 906 oz.[2]

South Africa.—A number of valuable platinum fields have been discovered in the Cala district of Cape Colony, South Africa. Regarding these deposits, which are situated in the Transkei, Dr. A. Heymann writes that the metal comes principally from the basic rocks, which are rich in magnesia, and is generally found in beds of sand or clay, which have been formed by the disintegration of the original platiniferous deposits. In these alluvials, or placers, as they are called, the metal occurs as flakes or grains, one of the chief impurities being titanic iron.

[1] *Min. Jour.*, Nov. 6, 1920.
[2] *Comm. Rept.*, Oct. 23, 1920, prepared by the Russian Division of the Bureau of Foreign and Domestic Commerce.

Diorite, olivines and quartzite are constituents of the deposits. As compared with the Ural deposits, those of this African region were found to lie nearer the surface, and the platiniferous strata appeared, as far as the tests went, to be even thicker than those of Russia. Regarding the deposits at Red Hill, it is stated that a decomposed rock, found at the surface, assayed 0.75 dwt. (18 grains) of platinum to the ton; at a depth of 4 ft. there was an average of 3 dwt. (72 grains = 0.15 oz.), while samples taken from a depth of 4 to 6 ft. gave as much as 16.25 dwt. (or about 0.8 oz.) per ton. Other samples, taken from five different localities, gave, respectively, 14.4, 30, 39.6, 42, 44.4, 63.6, and 297.6 grains, the latter being equivalent to 0.625 oz. per ton.[1]

The deposits are owned by the African Platinum Mines, Ltd., and this company is asserted to have the backing of several large concerns in Capetown.[2] The capital of the company is reported to be £150,000. In the new platinum field there are said to be large areas where platinum occurs in small quantities, but there are also sectional zones of concentration.[3]

In connection with the discoveries of platinum in the Cala district, it has been already noted that for several hundred miles along the margin of the Bushweld granite area in the Transvaal, pseudostratified segregations of chromite, associated with platinum, have been noted. These formations are several feet thick, and are said to be quite workable, although, as yet, they have not been exploited. In the copper-nickel deposits of Insigwa, Cape Province, platinum has been found in quantities ranging from 12 grains per ton to nearly 5 oz. per ton. However, this distribution is very irregular, but in any case should the deposit be worked for its copper content, the associated platinum would constitute a valuable by-product.[4]

Spain.—The platinum deposits in the Sierra de Ronda, in southern Spain, occur in an enormous outcrop of peridotites, with rhombic pyroxene dominating, surrounded by a border of gneisses metamorphosed in contact with the peridotites. The gneisses, débris of the ancient covering, are also to be found in the interior of the peridotic mass, and here also the contact of the peridotite and the gneiss is direct. It may be added that the forms of erosion of the peridotites offer no analogy with those of peridotic centers in the Urals. In the alluvial deposits the disposition of the platinum in the alluvial covering differs absolutely from that observable in the Urals. In the Spanish deposits the platinum, as is frequently the case with very recent auriferous alluvials, appears to be more or less regularly disseminated through the entire depth of the forma-

[1] *So. Afr. Min. Eng. Jour.*, Dec. 18, 1920.
[2] *Idem*, Sept. 4, 1920.
[3] *Idem*, Sept. 18, 1920.
[4] *So. Afr. Min. Eng. Jour.*, Sept. 18, 1920.

tion. In the Urals, on the other hand, the platinum, at least the industrial platinum, is exclusively concentrated in the layers of compact gravel, often argilaceous, termed *peskis* in Russia.[1]

In spite of the marked distinctions noted above, the discovery of platinum in the Ronda district by Señor Orueta resulted from his comparison of the eruptive rocks here with those of the platiniferous deposits of the Urals, as they had been described in 1911 by Prof. Duparc. This caused him to arrive at the conclusion that the peridotites of the Ronda district were also platiniferous. He therefore examined the alluvials of the rivers which traverse these peridotic masses, and he was rewarded in 1915 by finding platinum in all those which he tested.[2]

WORLD'S PRODUCTION OF NEW PLATINUM IN 1916–1919, BY COUNTRIES
(In troy ounces)

Country.	1916.	1917.	1918.	1919.
Russia, crude	(a)90,000	(a)110,000	(a)25,000	(a)30,000
Canada, crude (b)	(a)60	57	39	25
New South Wales and Tasmania, crude (c)	1222	330	1,606	1,326
Colombia, crude	25,000	32,000	35,000	35,000
United States, domestic crude	750	605	647	824
United States, refined from foreign and domestic matte and bullion (d)	2,556	7,384	.....	.....
Borneo and Sumatra and other crude (e)	(f)	(f)	(f)	(f)
Total	118,588	150,376	62,292	67,175

(a) Estimated. (b) In addition to platinum contained in matte and bullion refined in the United States. (c) Chiefly iridosmine. (d) Does not include refined platinum from domestic crude. (e) Includes small production in Madagascar. (f) No basis for estimate.

Technology and Bibliography

The production of platinum having a higher degree of purity than has heretofore been attained has been realized lately by the Bureau of Standards. It is claimed that Heræus platinum, long regarded as the standard for apparatus which requires the highest degree of purity, has been surpassed. This has been made possible by exercising a rigid control in the operation of smelting so that any calcium admixture can be almost entirely removed, as this admixture affects some of the physical properties of platinum.[3]

Extremely fine platinum wire, of a type that in pre-war times was mainly produced by the Germans, is now manufactured here by an American company. A platinum core is embedded in a silver wire and after the wire has been drawn out until it becomes very fine, the

[1] Louis Duparc, "Étude Comparée des Gîtes Platinifères de la Sierra de Ronda et de l'Oural," Geneva, 1916, by-print from Mém. de la Soc. de Phys. et d'Hist. Nat. de Genève, Vol. 38, fasc. 5, pp. 278, 279.

[2] *Op. cit.*, p. 254. Also Don Domingo de Orueta, "Resultado practico del estudio petrographico de la Serrania de Ronda," *Revista Minera*, Nov. 8, 1915.

[3] *Chem. Met. Eng.*, Apr. 20, 1921.

silver is removed by acid. The platinum wire that remains is of extraordinary fineness, being only 0.00006 in. in diameter. With a trifle less than 50 troy oz. of platinum (1555 gm.) it would therefore be possible to make a wire that would girdle the earth at the equator.

A new use of platinum has been noted by Donald W. Howe in an address before the Rochester section of the American Chemical Society. This concerns the employment of the metal as a hardener of vegetable oils. For this purpose "platinum black" is used, the material obtained by chemical combination of platinum with muriatic and nitric acid, and burning of the resulting platinum chloride on asbestos. The action of platinum black on the oils is similar to that produced by nickel.

The most authoritative and complete work on platinum and platinum deposits has very recently been published in Geneva by Louis Duparc, professor of mineralogy and petrology in the University of that city. Associated with him in the authorship was Marguerite N. Tikonovitch.[1]

No one could be better qualified to execute this task than Professor Duparc, who has long been known as the writer of many papers on the great platinum deposits of the Urals region in Russia, of which he has made a special study. He has also investigated personally the notable platinum deposits in other parts of the world, and the present work embodies the results of over twenty years of careful investigation as to the sources and exploitation of this rare and useful metal.

The work opens with a very comprehensive study of the topography and geology of the Ural region; this leads up to a chapter on the various "mother rocks" of platinum, and to a full description of the primary platiniferous centers, namely the dunites and peridotites, and to notes on the pyroxenites and koswites, as well as on the rocks of the gabbro family and other vein rocks, and on the metamorphosic rocks which appear in the eruptive platiniferous zone. Then the constituent elements of native platinum are presented, the condition in which it is found in the deposits, and the probable origin of the latter. To this succeeds a chemical section, giving a number of analyses of platinum ores and detailing the methods used in these investigations. The secondary deposits and the platiniferous alluvials are then passed in review. Following the exceedingly full description of the Uralian deposits, Professor Duparc more briefly treats of the platinum deposits in other parts of the world, in San Domingo, Honduras, equatorial Colombia, Brazil and French Guiana, in the United States, and in Mexico and British Columbia. Details are also given regarding the deposits of Oceania, Borneo, New South Wales, New Zealand and Tasmania. The African deposits of the

[1] Louis Duparc and Marguerite N. Tikonovitch, "Le Platine et les Gîtes Platinifères," Geneva, 1920, 600 pp., text ill., 90 stereotype pls., 11 in black and color, 8 of dredges, etc., atlas of Ural deposits, etc. Published by the Société Anonyme des Editions "Sonor," 46 Rue du Stand, Geneva; see also *Science*, N. S., **51**, 399–403, Apr. 23, 1920.

Transvaal are noted, as are the claims that Madagascar is a platinum producer.

The metallurgy of platinum and the methods used for the extraction and separation of the various metals of the platinum group are given at considerable length. To this very naturally succeeds a presentation of the different uses to which these metals have been put, and the work concludes with a chapter of statistics of platinum production. The first 100 copies of this great work were not in trade, and for each of the 500 copies numbered 101 to 600, subscribers were charged 100 francs, the price through booksellers being 125 francs. It must be borne in mind that these are Swiss francs, with only about 10 per cent. discount.

Another important publication in the platinum field is a new edition of the valuable bibliography of platinum literature by Prof. James Lewis Howe.[1] The first edition appeared in 1897 and was exclusively the work of Prof. Howe; in this second edition he acknowledges his indebtedness to a continuation by Dr. Hendrick Coenraad Holtz, then of Amsterdam, who carried the work down to 1910. This supplementary matter was completed by Prof. Howe, and all the literature was included up to 1916. A comparison of the number of titles given in these two successive editions of the bibliography will show how much more complete the second is than the first. In the edition of 1897 there were in all 2440 titles, but in that of 1917 the number is increased to 4561, not far from double. The titles are given in chronological order, those of each year being separately numbered. There is a complete, alphabetical author-index, which covers 29 pages, the literature for each subject being listed in chronological order, with the year and the author's name, as well as the year number under which it appears in the bibliography.

Due notice is taken in the bibliography of the annual platinum reports in "Mineral Resources" issued by the United States Geological Survey, where they have been treated successively since 1904 by David T. Day, F. W. Horton, Joseph Struthers, Waldemar Lindgren, and for the past 10 years by Dr. J. W. Hill. Companion pieces to these reports are the ones issued annually in our own publication since 1892, these having been furnished in the successive years by Charles Bullman, Henry Louis, Joseph Struthers, L. Tovey, Frederick W. Horton, F. Lynwood Garrison, and in the years 1916 to 1919 by the present writer, who also furnished the platinum data for the Eleventh Census (of 1890), with photographs he took while studying the Uralian deposits, and who contributed to the *Bulletin of the Pan-American Union* for November, 1917, a paper entitled

[1] "Bibliography of the Metals of the Platinum Group, Platinum, Palladium, Iridium, Rhodium, Osmium, Ruthenium, 1748–1917," by Jas. Lewis Howe and H. C. Holtz, Washington, D. C., 1919, 558 pp.; U. S. Geol. Surv. Bull. 694. The first, bearing only Prof. Howe's name, was published by the Smithsonian Institution, Washington, D. C. 1897, 318 pp.

"Platinum: with especial reference to Latin America," as well as a paper on palladium deposits of Brazil in a later issue of the Bulletin.

Among the monographs issued by the "Imperial Institute" on the mineral resources of the British Empire, is one by A. D. Lumb on "The Platinum Metals."[1] It contains a small-scale map of the world on which are marked the positions of the various platiniferous districts treated of in the text of the book.

[1] London, 1920, ix, 68 pp. 1 map.

POTASH

By Frederick W. Brown

The year 1920 opened with most of the American potash plants running full time on contracts which carried them well into the Spring. Imports in considerable volume had begun to arrive in December, 1919, and continued in increasing amounts through the Spring months, but there had been no carry-over from the preceding season; the demand for fertilizers was good and on the expiration of these contracts, the American companies were able to make new ones at prices which permitted operation even though the margin for profit was small.

This condition continued through the summer and early fall. In November came the beginning of general deflation, with the sharp drop in commodity prices. The fall fertilizer business proved negligible, and the fertilizer manufacturer suddenly awoke to the facts that the farmers were not paying their previous spring's fertilizer bills, that the demand for potash was likely to be much below normal in the season of 1921, and that foreign importations and American production had accumulated heavy stocks of potash in the country. Cancellations of contracts with American companies followed immediately and the end of the year found most of the plants closed and the few which were still operating facing a situation which would inevitably force suspension in a short time. As the evidence of a glutted market developed the price of potash declined steadily and soon reached a point below the actual cost of production for most American plants. In addition, as the general business situation became worse, distressed stocks of potash began coming on the market, with the result of further declines in price, until the situation reached the point of almost total stagnation so far as American production was concerned. One of the most important of the Nebraska companies, operating two large plants at Antioch, went into a receiver's hands in December.

American Production

Statistics compiled by the U. S. Potash Producers' Association show a production in 1920 of 184, 066 short tons of potash salts, equivalent to 49,232 tons of actual potash. These figures are not quite complete, as a few concerns believed to have produced small amounts during the year have failed to report although repeatedly requested to do so. The aggregate of these delinquent producers is too small, however, to modify the figures in more than a negligible degree.

The following tables present a fair picture of the industry's activities

during the past year. These tables have been prepared for comparison with the statistics issued in preceding years by the U. S. Geological Survey and by this office. The total of potassium oxide represents nearly a 60-per cent. increase over 1919 and almost equals the record production of 54,803 tons in 1918. But for the closing of a number of plants in November and December, 1920, the production last year would probably have exceeded the 1918 figures.

Of the 1920 totals, 88 per cent. of the potash salts and 85 per cent. of the actual potash were produced by members of the U. S. Potash Producers' Association. The year saw a notable shrinkage in the number of producing plants. In 1919, 77 plants reported production, while this year only 53 have reported. The largest reduction came in the case of cement mills where, instead of fourteen which reported production in 1919, only five have reported for 1920. Most of the eastern mills did not operate their potash-recovery plants last year. The following table shows production of potash in the United States during the past six years:

TABLE I.—POTASH PRODUCED IN THE UNITED STATES, 1915–1920

Year.	Number of Producers.		Production.		
	Total.	Exclusive of Wood-ash Producers.	Crude Potash (Short Tons).	Available Content of Potash (K_2O) (Short Tons).	Average K_2O Percentage in Crude Salts.
1915	5	5	4,374	1,090	24.9
1916	70	25	35,739	9,720	27.2
1917	95	46	126,961	32,573	25.6
1918	128	77	207,686	54,803	26.4
1919	77	45	119,736	32,418	27.0
1920	53	34	184,066	49,232	26.7

Natural brines continue to be the largest single source of potash, and last year produced 77 per cent. of the total output. The Nebraska lakes led the country with 43 per cent., and brines in Utah and California produced 34 per cent. The following table gives the production for 1920 from the various United States sources:

TABLE II.—POTASH PRODUCED IN THE U. S. IN 1920, CLASSIFIED BY SOURCES

Sources.	Number of Producers.	Potash Salts, Tons.	Actual Potash (K_2O), Tons.	Per Cent. of Total.
Natural brines:				
Nebraska lakes	8	84,394	21,439	43.5
Other brines	5	52,151	16,688	33.9
Molasses distillery	4	9,882	3,433	7.0
Steffens waste water	3	8,609	3,325	6.8
Alunite, silicates and kelp	4	4,562	2,282	4.6
Cement-mill dust	5	21,596	1,583	3.2
Wood ashes	19	453	299	0.6
Blast-furnace dust	5	2,419	183	0.4
Total	53	184,066	49,232	100.0

About 57 per cent. of our production of actual potash came to market in the form of crude mixed salts, which includes the entire Nebraska lake production and the output from sugar mills and molasses distilleries. High-grade muriate constituted 26 per cent., low-grade muriate 8.7 per cent., and sulphate 5.3 per cent., of the total. The following table shows the production classified by the form of the product:

TABLE III.—POTASH PRODUCED IN THE UNITED STATES IN 1920, CLASSIFIED ACCORDING TO THE FORM OF THE PRODUCT

Potash Material.	Crude Potash (Short Tons).	Content of Potash, K_2O Available.		
		K_2O Percentage.	Quantity (Short Tons).	Percentage of Total.
Crude mixed salts	102,885	8–44	28,197	57.3
Muriate	23,970	35–57	12,745	25.9
Sulphate	5,663	35–54	2,621	5.3
Low-grade chloride	28,894	8–16	4,299	8.7
Crude carbonate	339	40–70	205	.4
Caustic	115	72–88	95	.2
Cement and blast-furnace dust	22,100	2–13	1,060	2.1
Miscellaneous	100	10	10	.....
Total	184,066	.....	49,232	99.9

Nebraska, with eight producing plants, led the country with 84,394 tons of salts, representing 21,439 tons of K_2O, or 43 per cent. of the total. California, with eleven plants, stood second with about 26 per cent., and Utah third with 21 per cent. These three States produced over 90 per cent. of our total output of potash salts and very close to 90 per cent. of our actual potash. The following table shows our production by states:

TABLE IV.—POTASH PRODUCTION IN 1920 BY STATES

State.	Number of Plants.	Crude Salts (Short Tons).	Available Content of Potash, K_2O.	
			Quantity (Short Tons).	Percentage of Total.
Nebraska	8	84,394	21,439	43.5
California	11	42,641	12,561	25.5
Utah	3	40,695	10,282	20.9
Pennsylvania	5	2,419	183	.4
New York, New Jersey, Maryland, Virginia	4	6,564	1,739	3.5
Ohio, Colorado, Porto Rico	4	6,906	2,733	5.5
Wisconsin	10	349	231	.5
Michigan	8	98	64	.2
Total	53	184,066	49,232	100.0

The Nebraska Field

The production from Nebraska lakes was practically limited to the eight large plants, all the smaller companies having gone out of business either in the preceding year or early in 1920. The Potash Reduction Co. at Hoffland, the American Potash Co. (two plants), the Nebraska Potash Works Co., the Alliance Potash Co. and the Union Potash Co. at Antioch, and the Hord Potash Co. and the Standard Potash Co. at Lakeside, turned out an aggregate of nearly 85,000 tons of potash salts, equivalent to over 21,000 tons of actual potash (K_2O).

This production was accomplished in the face of an almost unprecedented rainfall during the spring and summer, which lowered the concentration of the brine in the lakes so that some of the plants were forced to work with water carrying only 2½ per cent. of solids instead of the 5 per cent. generally considered necessary for economic operation. As the plant capacities in evaporators and driers were fixed quantities, the low-grade brine cut down the output of salts very seriously, while correspondingly increasing the cost per ton.

The Alliance Potash Co. closed its plant in November and early in December the American's two plants and the Union company's plant were shut down. In view of these circumstances, the aggregate output from the Nebraska field makes a very creditable showing.

Active experimentation on a large scale was carried on during the year by several of the companies, with the object of effecting a separation of the salts. This would make possible the production of a sulphate of potash carrying 45 per cent. K_2O instead of the present mixed carbonate and sulphate of 25-per cent. grade, and would also give a by-product in the form of soda ash or caustic soda. The successful operation of one or more of these separation processes seems reasonably assured as a result of the work done during the year. This will effect economies by furnishing a valuable by-product, and also by lowering the freight-rate per unit on the potash shipped.

Searles Lake

The American Trona Corporation and the Borosolvay Co., the latter controlled by the Solvay Process Co., continued operations at Searles Lake, and turned out a high-grade product in the form of 90-per cent. potassium chloride. The material as shipped contained less than one-half of one per cent. anhydrous borax and was pronounced entirely satisfactory by agricultural experts and by the fertilizer companies. Considerable quantities of the product were also taken by chemical concerns for the production of caustic potash by the electrolytic process, for which it is peculiarly suited owing to its low content of sulphates.

The West End Chemical Co. continued with its construction work and expects to be in a postition to produce during 1921.

A new development at Searles Lake during the year was the plant of G. P. Burnham, which was recently described by L. W. Chapman as follows:

> A fourth process is operated at Searles Lake, the distinctive feature being the use of solar evaporation only for the production of borax and potash. The process is the invention of G. P. Burnham. Advantage is taken of fractional crystallization at different concentrations and temperatures, and the brine is so manipulated that the various salts come down separately in different ponds. The rate of evaporation from brine at Searles Lake is about 6 ft. per year. The brine contains 80 tons of KCl and 50 tons of borax per acre-foot, so that a 100-acre pond evaporating continuously will deposit 48,000 tons of potash and 30,000 tons of borax per annum.
>
> In the Burnham process several ponds are provided and the potash is made by flowing the brine into shallow ponds during the summer days, then into deep ponds at night, in order to retain the heat. By continuing the process warm evaporation is maintained until the brine becomes concentrated with potassium chloride. At this point the brine is circulated between two shallow ponds, and cooling at night crystallizes out potassium chloride in one pond and during the day further warm evaporation crystallizes out sodium chloride in the other.
>
> Borax is made by flowing the brine into shallow ponds at night during the winter to cool, sodium sulphate and sodium carbonate being deposited. When the brine is coolest in the early morning, it is flowed in deep ponds where the tenperature is maintained for several days, borax gradually crystallizing out.

Salduro Marsh

At Salduro, Utah, the Utah-Salduro Co. produced more potash in 1920 than any other American plant. Because of the peculiar meteorological conditions in this locality it is possible to turn out a salt carrying 15 per cent. K_2O by solar evaporation alone. The rainfall is negligible and the summers are very hot. It has always been the intention of the company to refine this material to an 85-per cent. chloride before shipment and this was done with a large part of the 1920 crop. Market conditions were such, however, during the early part of the year that it was profitable to ship even the low-grade material, and to some extent this was done.

Two other companies are interested in the brine of Salduro Marsh. The Diamond Potash Co. operated a small plant at Arinosa to the east of the Utah-Salduro plant, and the Bonneville company has acquired leases and patents to the west, close to the Nevada-Utah line, and contemplates the construction of a large plant in the near future.

Alunite

The Mineral Products Co., a subsidiary of the Armour Fertilizer Works, ran its plant near Marysvale, Utah, and produced high-grade

sulphate of potash from alunite until late in the year, when the accumulation of stocks and the low price of potash necessitated closing down. Practically the entire output of the plant went to the parent company for fertilizer mixing purposes.

No other company operated on alunite in Utah, though small quantities of the rock were shipped east and treated by the Stoner Chemical Co. of Alexandria, Va., for the production of potash alum.

By-product Sources

Eastern cement mills for the most part did not run their potash recovery systems during 1920. The product of the eastern mills is a low-grade chloride carrying from 2 to 10 per cent. K_2O, the sale of which in competition with German and French kainit proved impossible. On the other hand the costs of refining the material have so far been prohibitive. Two of the western cement mills, the Riverside Portland Cement Co. and the Santa Cruz Portland Cement Co., both using oil-fired kilns, produced sulphate of potash throughout the year and marketed it at a profit.

The latter company's success in turning out a relatively high-grade product is worthy of comment. So far as known the installation at this plant has not been described in detail in any of the technical journals. Briefly, the process is as follows: The gases from the kilns are passed through wet washers where all dust is removed. The slurry from the washers is returned to the kilns, thus avoiding loss of potash at this point. From the washers the gases are drawn into a large chamber with an outlet in the peak of the roof, guarded by Cottrell-treater plates. The salts are deposited in a light flocculent form on the walls and floor of this chamber. Mechanical scrapers draw the material to a central slot in the floor through which it falls between steel rolls directly into the bags ready for shipment. The material so collected averages 60 per cent. potassium sulphate, or 32 per cent. K_2O.

Three companies, the Mason By-Products Co. and the Western Industries Co. of San Francisco, and the United States Industrial Chemical Co. at Baltimore, produced by-product potash from molasses distillery waste and operated continuously during 1920. Their product is a fertilizer potash in the form of a mixed carbonate and sulphate carrying better than 30 per cent. K_2O.

The American Beet Sugar Co., with a plant at Oxnard, Calif., and the Great Western Sugar Co., with four plants in Colorado and Nebraska, produced a similar fertilizer potash in considerable quantity. These plants are operated seasonally for three or four months each year, either simultaneously with the sugar campaign or immediately following it.

IMPORTS

The importation of European potash from the mines in Germany and France took a sudden upward jump in December, 1919. This movement continued, the monthly importations advancing from 10,800 tons of K_2O in December, 1919, to 32,800 tons of K_2O in March, 1920. This was the peak, however, and thereafter the amounts received monthly decreased and for the latter half of the year an average of about 13,000 tons of K_2O per month was maintained.

Of the so-called "fertilizer potash" salts, consisting of kainit, manure salts, muriate and sulphate, an aggregate of 918,057 short tons was imported, equivalent roughly to 200,000 tons of K_2O. In addition, 63,510 tons of various potash salts not ordinarily used for fertilizer entered our ports, equivalent to about 20,000 tons of K_2O. The total importations therefore amounted to 981,567 tons of salts, equivalent to about 220,000 tons of actual potash. As approximately 50,000 tons of K_2O was produced in this country, it is apparent that the available supply in 1920 was equal to the available supply in 1913, when 270,000 tons was imported and none was produced here.

The following table shows the imports of the more important potash salts for the years 1916-1920 inclusive, together with the declared values:

TABLE V.—IMPORTS OF POTASSIUM SALTS
(In tons of 2000 lb.)

	1918.		1919.		1920.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Kainit	.....	.....	57,427	$921,481	416,661	$8,212,621
Manure salts	.....	.....	45,372	1,269,750	348,837	10,625,717
Muriate	424	$102,109	23,202	1,783,916	136,195	12,703,858
Sulphate	101	15,329	1,415	188,592	17,006	2,343,431
Bicarbonate	36	34,279	24	8,921	194	93,565
Bitartrate (argol)	14,041	4,782,267	12,904	4,311,610	17,726	4,452,428
Bitartrate (cream of tartar)	7	3,355	12	10,879	109	83,903
Carbonate, crude	4,297	2,273,202	258	104,744	8,452	510,700
Carbonate, crude black salts	228	47,956	102	10,075	7,356	417,797
Carbonate, refined	104	65,974	23	9,665	882	290,354
Caustic	.....	.....	242	134,166	856	451,274
Chlorate	355	248,160	100	34,996	742	162,417
Chromate and bichromate	.....	8	8	4,271	2	2,690
Cyanide	12	10,278	588	68,848	7,224	1,088,247
Ferricyanide (red prussiate)	8	29,201	17	18,096	51	64,686
Ferrocyanide (yellow prussiate)	65	112,729	258	122,372	381	105,962
Iodide	32	142,324	9	54,250	3	14,872
Nitrate (saltpeter) crude	4,672	906,549	18,826	1,107,313	18,816	1,599,346
Nitrate (saltpeter) refined	2	730	37	8,171	631	107,154
Permanganate	27	128,438	2	10,163	27	29,748
Rochelle salt	8	4,948	20	9,537	59	29,013

POTASH IN FOREIGN COUNTRIES

Germany.—After a year of great prosperity in 1919, when some of the companies paid dividends of 20 per cent., the German potash producers

have been complaining of a falling-off in business during the latter part of 1920. The Potash Syndicate states that the total production of potash salts in 1920 amounted to 11,386,439 metric tons. Compared with 1919, when 7,772,036 metric tons was produced, the 1920 output showed an increase of more than 3,000,000 metric tons, as well as a most favorable comparison with production in pre-war years, as is shown in the following table:

TABLE VI.—PRODUCTION OF GERMAN POTASH SALTS.
(In metric tons)

Year.	Production.	Year.	Production.
1911	9,706,507	1916	8,642,887
1912	11,070,014	1917	8,938,738
1913	11,607,510	1918	9,438,251
1914	8,171,512	1919	7,772,036
1915	6,897,476	1920	11,386,439

TABLE VII.—GERMAN POTASH SALES
(In short tons of K_2O)

Year.	Domestic Sales, Tons.	Foreign Sales, Tons.	Total, Tons.
1911	527,822	441,941	969,763
1912	581,422	524,514	1,105,936
1913	664,711	556,695	1,221,406
1914	591,590	402,797	994,387
1915	623,807	123,947	747,754
1916	797,548	174,825	972,373
1917	958,625	146,084	1,104,709
1918	945,688	156,142	1,101,830
1919	700,735	192,466	893,201
1920	.....	.....	1,018,132

While the costs of production in Germany have increased as measured in marks, the foreign-exchange situation at present gives German producers a tremendous advantage over their foreign competitors. The purchasing power of the mark in Germany is at least four times its purchasing power in American exchange. In 1913 a German workman receiving 3 marks per day was paid the equivalent of about 72 cts. In 1920 the same workman getting, say, 20 marks is nominally being paid nearly seven times his former wage. At current exchange of, say, 2 cts. to the mark, however, he is getting the equivalent of 40 cts., and in purchasing power in Germany, about $1.60, so that whereas his wage has apparently been increased nearly seven times, it has in fact been only a little more than doubled.

A German exporter demanding payment, as the Potash Syndicate does, in dollars, receives the equivalent not of 420 marks for every hundred dollars as he did in 1913, but of 5000 marks, which will buy him in Germany at least $400 worth of labor or materials, or four times what it will buy in the United States.

German producers, in asking Government sanction for an increase in the price of domestic potash salts, stated that domestic sales were being made at a loss and that their profits in 1919 had come from the favorable exchange situation on their export business.

France.—All but two of the Alsatian potash shafts were still in the hands of the French Government sequestrator during 1920. The Government has, however, been authorized to purchase all the mines and lease them to private companies for operation. Pending this action a central sales company has been formed, the Société Commerciale des Potasses d'Alsace, to control distribution from all the mines. This company has established a sales agency in New York and is making a strong effort to secure the American business. Imports of French potash increased toward the end of 1920, and at the end of the year very considerable quantities were in storage in this country.

Commercial Attaché Huntington, at Paris, has transmitted comparative statistics on the Alsatian potash situation.[1]

The total production of the Alsatian mines in 1913 was 350,341 metric tons, corresponding to 56,000 tons of pure potash; in 1919 the production was 464,607 tons, corresponding to 92,006 tons of pure potash; and in 1920 the total reached 1,061,191 tons, corresponding to 199,230 tons of pure potash.

The following shows the amount of the 1919 production of the grades named compared with the production of 1920:

Grades.	1919.	1920.
	Tons.	*Tons.*
Sylvinite, 12 to 16 per cent	262,779	664,619
Rich sylvinite, 20 to 22 per cent	163,714	335,820
Chloride of potassium, 50 to 60 per cent	38,114	61,352
Total	464,607	1,061,191

Shipments during 1919 and 1920, expressed in terms of pure potash, were in amount as follows:

Grades.	To France.		To United States.		To Other Countries.	
	1919.	1920.	1919.	1920.	1919.	1920.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Sylvinite, 12 to 16 per cent	20,820	43,994	11,022	27,355	6,303	25,557
Rich sylvinite 20 to 22 per cent	16,260	31,420	8,276	19,720	9,096	17,679
Chloride of potassium, 50 to 60 per cent.	9,973	11,164	3,849	8,892	6,407	11,394
Total	47,053	86,578	23,147	55,967	21,806	56,630

[1] *Comm. Rept.*, May 23, 1921.

Since March, 1921, the concentration plants of the Alsatian potash mines have been manufacturing rich sylvinite of 30 per cent. K_2O content and sylvinite of 40 per cent. K_2O content.

For the time being competition between French and German producers for the American business seems certain, but the loss of profits which this will inevitably entail will in time force these groups into some agreement to maintain prices.

Abyssinia.—The Italian Societa Mineraria Coloniale began operations on the Abyssinian potash deposits in 1915 under a 35-year concession from the Abyssinian Government. In 1917 the shipments amounted to 3944 short tons. A port has been built at the nearest point on the Red Sea, known as Mersa Fatimari, and from here a narrow-gauge railway leads through Italian Eritrea to the Abyssinian frontier. A wagon-road runs from the frontier 10 miles to the deposits. Motor-trucks are used to transport the potash. The material is muriate of 90-per cent. grade as mined. It is claimed that from 5000 to 8000 tons a month could be supplied. The claim is also made that the deposits are fed continually by warm springs and that potash removed is rapidly replaced.

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PRECIOUS STONES

By George F. Kunz

The mining and search for diamonds and other precious stones has been actively pursued for the greater part of the year 1920 the extraordinary demand for them offering much encouragement. In 1919 the imports of precious stones and pearls into the United States reached the unexampled total of $105,273,543; in 1920 these heavy imports continued, the total for January–June being $51,447,699, but in the latter half of the year a reaction set in, and during the period July–December the imports fell to $24,307,892, against $33,861,348 for these months in 1919. Still, this gives for the whole of 1920 $75,775,591, a higher figure than for any other year except 1919. The steady and effective control exercised by the London Diamond Syndicate has sufficed to maintain prices.

The marked decrease in precious-stone imports for the year 1920 is best exhibited by the following table of the monthly imports of the year:

January	$10,830,617	July	$4,279,026
February	11,125,033	August	3,884,035
March	10,611,089	September	3,475,029
April	8,532,271	October	5,262,602
May	5,555,917	November	4,264,320
June	4,792,772	December	3,142,880
Total	$51,447,699	Total	$24,307,892

IMPORTS OF DIAMONDS AND OTHER PRECIOUS STONES INTO THE UNITED STATES

	1917.	1918.	1919.	1920.
Diamonds, glaziers' and engravers', unset and miners', free	$1,098,102	$718,397	$984,381	$1,527,753
Diamonds, uncut, dutiable	13,091,582	12,605,526	20,315,758	10,527,363
Diamonds, cut but not set, dutiable	18,416,570	7,761,810	64,222,947	45,444,999
Pearls and parts of, not strung or set, dutiable	4,898,406	722,981	11,541,000	7,377,772
Other precious stones and bort, dutiable	482,224	604,550	1,623,522	3,717,741
Other precious and semi-precious stones, cut, but not set, dutiable	1,752,384	968,094	5,006,032	5,031,639
Imitation precious stones, dutiable	1,167,399	890,642	1,579,903	2,228,325
	$40,906,667	$24,272,000	$105,273,543	$75,855,591

IMPORTS OF CUT DIAMONDS AND PEARLS ACCORDING TO THE SOURCE

	Diamonds, cut, but not set, dut.			Pearls, and parts of, not strung, nor set, dut.		
	1918.	1919.	1920.	1918.	1919.	1920.
Imported from:						
France	$170,441	$2,033,268	$2,506,090	$112,580	$5,982,654	$3,861,617
Netherlands	6,266,319	53,561,019	31,024,241	.....	.....	.....
United Kingdom	1,308,941	6,664,911	3,003,534	376,741	5,347,460	3,235,320
British India	.....	.....	.....	150,097	81,003	79,452
Other countries	16,109	1,963,749	8,911,134	83,563	129,883	201,383
Totals	$7,761,810	$64,222,947	$45,444,999	$722,981	$11,541,000	$7,377,772

The large increase in the 1920 imports of cut diamonds from "other countries" over the figures for 1919 shows essentially the resurrection of the Antwerp market in the face of a heavy falling-off in the imports from Amsterdam. We have an increase in 1920 of nearly $7,000,000 as compared with 1919 for "other countries" (including Belgium), as against a falling-off of $22,500,000 for the Netherlands (Amsterdam).

From May 1, 1919 to April 30, 1920, the precious-stone imports reached the high-water mark of $122,816,489, a figure that has never been approached before or since. Itemized these importations would be as follows:

Diamonds, glaziers' and engravers', unset and miners'	$1,178,512
Diamonds, uncut	18,479,571
Diamonds, cut, but not set	78,716,142
Pearls, and parts of, not strung or set	13,258,935
Other precious stones, uncut, and bort	3,469,461
Other precious and semiprecious stones, cut, but not set	5,868,187
Imitation precious stones	1,845,681
Total	$122,816,489

On the whole it can be said to mark the climax of the greatest period in the precious-stone and jewelry industry which the United States has ever known, but toward the middle of the year, as has been noted, the tide began to turn. The unsuccessful jewelry strike, lasting from November, 1920, to March, 1921, involving the claim of the workers to an increase of remuneration to $3 an hour, stipulating a 39-hr. week, coupled with a provision that one and a half times the ordinary pay was to be received for every extra hour's work, meant that jewels rather than jewelry were sold.

The great and widespread plentifulness of money enjoyed by the precious-stone industry had been largely due to war profits and bumper crops and phenomenal mine outputs of the West and the high prices realized because of the urgent European demand in the period immediately succeeding the war; to this was added the great production of copper, and of the oil of Oklahoma and Texas. Then the prices of these commodities began to fall as a result of the war reaction, and, moreover, the demand for engagement and wedding jewels which had been stimulated by the great army of soldiers and the enthusiasm incident to our victories, began to abate.

In the meanwhile the effects of undue speculation began to make themselves felt. Toward the climax of the rise, it frequently happened that a jeweler who had engaged and bought a quantity of rough or partly-cut diamonds was able to sell them to another jeweler at an advance of 10 or even 25 per cent. before they had been received, and in not a few cases the second purchaser was able to pass them on at an equal profit to a third aspirant, and the latter to still another eager buyer, so

that sometimes from two to six separate profits remained to be realized by the last purchaser. Naturally enough, when prices began to fall, the latter found himself in a very uncomfortable position, and occasionally suffered disastrous effects, although those who had avoided the danger of being swept along by this wave of excitement were safe enough. Still the check in distribution operated to halt the demand in the foreign centers, and although prices were maintained and the market was steadied by shutting down the South African mines to a great extent, the volume of imports fell off rapidly.

The semi-precious stone industry has somewhat changed with the great demand for Burmese jadeite, generally cut in China. Many California stones, such as rubellite, agate, etc., were also cut in China, and there have been great quantities of Madagascar gems. Beryls and tourmalines, rose-quartz and amazon stones have been cut in France and Germany, and also in Italy by German workers, who had migrated thither. To these should be added rock crystal and smoky quartz, the latter being often decolorized to citrine, the so-called "topaz" of the jewelers. There was also onyx, cut into many small forms, to be used as accessories in diamond jewelry, to be strung as rondelles or as beads, interspersed with beads of rock crystal and other semi-precious materials.

Germany.—The jewelry industry in Germany shows signs of a revival from the depression due to Germany's defeat in the World War. This is exemplified by recent reports from the great German jewelry center, Pforzheim in Baden. In spite of the cutting off during the war of direct foreign relations with their best customers, the jewelers of Pforzheim were able to preserve a part of their trade through neutral channels; after the conclusion of hostilities there sprang up a home demand for Pforzheim goods and also a good demand from foreign buyers. Since then, through the occasionally disturbed internal conditions, the industry has suffered some setbacks, and it has to contend with a very heavy export duty levied by the German Government, this amounting recently to about 1,000,000 marks a month, at least $16,000 in terms of exchange, but really much more when computed according to the purchasing power of the mark in Germany. At present there are about 800 jewelry concerns in Pforzheim, the largest being the Kollmar & Jourdan Co., which employs about 2000 workers. The price movement toward the close of the war and after the conclusion of peace has been very extraordinary. By July, 1917, prices had risen 75 per cent. and by December of this year 125 per cent. Early in September, 1919, the added cost was 225 per cent. over pre-war figures, in early December, 1919, 500 per cent., and in February, 1920, the maximum increase of 800 per cent. was recorded. By May, 1920, the increase had fallen to 600 per cent.

and by August, 1920, to 450 per cent. Naturally this refers to prices in marks, and depended quite as much on the fluctuating value of the monetary unit as upon other economic considerations. On the whole, in spite of the many drawbacks which still exist and the strenuous efforts made to oust Pforzheim from the South American markets, of which this jewelry industry had strong control, the prospects for the future are pronounced to be far from unfavorable.[1]

Later advices seem to show that the slow recovery of the Pforzheim industry still continues. In order to combat the tendency to an undue reduction of prices the manufacturers and traders have organized their 24 professional associations into a central syndicate, which keeps itself in close touch with the export offices. As to the present aspect of things, the *Frankfurter Zeitung* remarks:[2]

"The exports in Norway, Sweden, Italy, Austria and Holland are impeded by restrictive measures, the difference of exchange or other obstacles. The United States does not enter much into account . . . the Americans are endeavoring by all possible means to establish an industry among themselves capable of supplanting that of Pforzheim. The remainder of the markets of the world are either well supplied with goods, or have not, for want of money, any capacity for purchase. We cannot, therefore, rely too much on the States of Central and South America, which for more than half a century have been Pforzheim's best clients, but where the rapid decrease of productions of the soil and the fluctuations of exchange have disorganized business . . . If we are to believe letters from the Argentine, Brazil and Cuba, these three countries, loyal clients of German jewelry, will be the first to return to it."

The German writer finds that out of 200,000,000 marks' worth of jewelry sold annually in pre-war times from Pforzheim, 75 per cent. represented purchases made by foreigners. The main factors of the strength of the industry in its present difficulties are the capacity for assimilation and adaption on the part of the manufacturers, and the highly developed technique possessed by the 35,000 or 40,000 workers engaged in the industry.

Diamonds

How glaringly inexact were the statements in an article on diamond prices which has recently gone the rounds of our newspapers, is brought out convincingly by the statement therein contained that, while early in 1920 uncut diamonds were worth $45 a carat, their price had gone down to $28 a carat in December of that year, and had "slumped" to $17 a carat by April, 1921. Now the actual figures, as given in the official treasury reports of imports, show that the average value of uncut diamonds for the entire year 1920 was $86.12 and for the month of Decem-

[1] Thomas Reece, London, *The Manufacturing Jeweler*, 1920, p. 772.
[2] As cited in the *Watchmaker, Jeweler, Silversmith and Optician*, May, 1921, p. 935.

ber $78.18. For the first three months of 1921, the average per carat was $79.61. Although there was a decrease in March as compared with February, this evidently reflected a greater importation of small diamonds for the summer trade, for a similar change in average values is shown in 1920, and is apparent from the following figures for the two years:

	1920.	1921.
January	$68.14	$80.88
February	94.39	93.04
March	58.82	59.47

Thus it will be seen that the variations, though considerable, are not in the least indicative of any continuous movement in values, but only of temporary changes in the character of the parcels imported.

Diamond-cutting and Trade

France.—The French diamond-cutting industry of the region of Saint-Claude in the Jura Mountains appears to be in quite a flourishing condition at present. There are as many as 57 factories in operation there, giving work to some 1600 diamond-cutters. However, only three or four of these factories are large ones, many of the remainder being conducted by a single master workman with three or four assistants. Nevertheless, it is reported that the output of cut diamonds for the last six months of 1919 equaled 40,000 carats. Besides this old-established cutting industry at Saint-Claude, factories in Paris and in Nemours gave employment to 250 men, and there are small diamond-cutting works in a number of other French localities, such as Felletin, Lyons, Nice, Guimper, Bourg, Bellegarde, and in several places in the department of Haute-Savoie. Still there is a recognizable inferiority in much of the French work, due it is said to the imperfect instruction of apprentices. This want is about to be remedied by the founding of a diamond-cutting school at Saint-Claude.[1]

The conditions of the gem-cutting industry in Paris are reported to be greatly in need of improvement, for although there are some quite well organized establishments, the smaller ones leave much to be desired. To remedy this an active movement has been initiated by the friends of this industry in Paris for the establishment of a factory equipped with about a hundred mills. By this means and by a more thorough organization of the training of apprentices, it is confidently believed that a great change for the better will soon be realized. In the meanwhile an appeal has been made to those who have stones to be cut, that they shall not too exclusively favor the cutters of the Jura region at the expense of the Paris workers.[2]

[1] *La Nature*, June 19, 1920.

[2] *Recueil Mensuel des Procès-Verbaux des Séances de la Chambre Syndicale des Négociants en Diamants, Perles, Pierres Précieuses, et des Lapidaires*, No. 48, Jan.–Feb., 1921, pp. 809–810.

Great Britain.—The experiment of Sir Bernard Oppenheimer in establishing a diamond-cutting factory to utilize the labor of disabled soldiers appears to have met with striking success. Beginning on a very small scale in July, 1917, it has now developed into the largest diamond-cutting factory in the world, and the great English seaside resort Brighton is destined to figure as a prominent center of the diamond industry, alongside of Antwerp and Amsterdam. At the end of 1920, as many as 700 hands were employed here, and provision has been made for increasing the number of workers to 2000. During the first six months of training the men receive an allowance from the Ministry of Labor, in lieu of their pension, no wages being paid to them by the firm, but free expert instruction being provided for them. At the expiration of the six months' training, the ex-soldier again receives his pension from the Ministry of Pensions, and is given a weekly wage of £2 by the firm. As he becomes more proficient, his remuneration is increased, and by the end of his first year an average cutter earns £3 a week; in the second year this average rises to over £5 a week. If expectations are fulfilled, the British Empire will soon be not only the chief producer of diamonds, but will also have a large share of the profits derived from cutting the stones mined in British dominions.[1]

As an indication of this, it is stated that diamonds valued at £500,000 have not long since been shipped to Antwerp. In addition, orders from the East have reached a value of £300,000, and exports have been made to Paris and New York. A diamond weighing 600 carats, the largest received up to the middle of November, 1920, was cut into 40 stones of considerable size and a number of smaller ones. The industry does not depend solely upon South African diamonds, for rough diamonds to the value of £250,000 have been received from British Guiana and cut at Brighton. The machinery used is manufactured in Sussex County, and thus any needed part can be duplicated and replaced with very little delay. As has been stated, the work at Brighton is done exclusively by disabled soldiers of the World War, instructed in the diamond-cutters' art by expert Belgian workers who sought refuge in England during the German occupation of their native country.

Netherlands.—The diamond industry in the Netherlands has been taking active measures to resist the depression that set in after the middle of 1920. Encouraged by the resolute determination of the London Diamond Syndicate to maintain prices, a meeting of representatives of the diamond industry in Amsterdam was held in December, 1920, and passed the following resolutions:

[1] *So. Afr. Min. Eng. Jour.*, Dec. 18, 1920.

Whereas (1) there is no reason to reduce the price of a polished product, because the maintaining of prices by the English Rough Syndicate makes it impossible to replace the goods cheaper; (2) the production of diamonds is limited; and (3) there is great confidence all over the world in the value of diamonds, which cannot be considered merely articles of luxury, but have proved themselves to be solid investments; therefore, be it

Resolved (1) That, if necessary, we will assist financially the smaller concerns to prevent forced sales, and (2) that we will take most stringent action against any individual or firm, buyer or seller, making any attempt whatsoever to try to force prices down.

The details of these measures will be worked out carefully at the next meeting.

In July, 1920, it was reported that the Amsterdam diamond-cutting factories were seriously handicapped by the low exchange value of the Belgian franc, as this rendered it possible to have rough diamonds cut in Antwerp for less money than in Amsterdam. To offset the disadvantages for the Amsterdam cutters the employers have replaced the fixed surplus on cutters' wages by a sliding-scale, so that the surplus will move down as Belgian exchange drops. This measure, however, was not so successful as was expected, since the Antwerp employers reduced wages to counterbalance the reduction in Amsterdam. In the opinion of experts the crisis in Amsterdam last July was the most serious so far experienced, and the number of unemployed workers in the diamond industry had risen to 7100. The prohibition of diamond imports into France has been a depressing factor, especially as the American exports had also fallen off somewhat. The demand from Germany due to the sudden fall in value of the mark, which encouraged a feverish rush to buy diamonds and other valuable and portable objects lest the mark should lose all but a nominal value, was checked by a recovery in German exchange in the summer.[1] Late reports as to the unemployment of diamond workers in Amsterdam are very discouraging as it is said that on Apr. 1, 1921, 8328 of the 10,000 workmen engaged in the industry were out of employment, an increase of 350 over the report for June–Aug. 1, 1920.

In view of the immense number of diamonds that are cut and polished in Amsterdam, it is but natural that the systematic recovery of the diamond-dust is more highly developed there than in other places. The friction of the stone on the polishing disc, which is smeared with olive oil and diamond-dust, causes the formation of a muddy deposit composed of the oil and dust, and the exceedingly fine particles of the latter are successfully extracted from the "waste." The profits derived from this recovered diamond-dust have been donated to the Koperen Stelen Fund for the care of the tuberculosis patients among the diamond-

[1] *Holland's Import and Export Trader*, July 19, 1920, p. 356.

workers. In the first year of this donation as much as 100,000 florins (over $40,000) was paid over to the Fund from this source, for as much as a half liter of waste is collected in the polishing rooms in a single day. This charitable organization has acquired 215 acres of ground in the pine woods at Hilversum, and a large Sanatorium is to be erected there affording accommodations for 150 adults and 50 children. To carry out this work 700,000 florins must be expended, so that any notable diminution of activity in the Amsterdam diamond industry will be attended with bad results for this benevolent enterprise.[1]

Diamond Mining and Production

The different diamond fields of the world have produced in the whole course of their exploitation diamonds valued at about the following sums.

India	$50,000,000
Brazil	150,000,000
German S. W. Africa	35,000,000
Borneo	1,000,000
South Africa	950,000,000
	$1,186,000,000

After adding the expense of cutting, the amount paid for duties and the cost of selling the cut stones, we may safely estimate that the eventual price paid for these diamonds has been close to $3,000,000,000.

Borneo.—The prospect of an increased diamond production in the Dutch East Indian colony, Borneo, is discussed by Mr. H. J. van der Munnik, in *Commercial Holland* for August, 1920.[2] The question was drawn to the attention of the Dutch Government in 1917, in the First Chamber of the States General of the Netherlands, but very little has been heard of the matter since then, although some enthusiastic explorers have expressed the opinion that in the Matapoera fields of Borneo riches may be found rivaling those of Kimberley. Matapoera is only an hour's ride by motor car from Bandjermassin, and a diamond mine is already being operated there by a couple of hundred workers. There are also diamond-cutting works, where Borneo diamonds, and also some from Capetown, are cut and polished, and many of these are to be seen in the rich jeweling of East Indian potentates.

The first governmental inquiry dates back to 1893 and resulted in a concession to certain French mining experts; this terminated in 1905. Renewed investigations, carried on by the explorer Captain Christoffel in 1911, procured him rights over a district of about 250,000 acres, principally of marshy ground. He endeavored to interest the Amsterdam jewel merchants in the project of founding a syndicate for the exploita-

[1] "The Dutch Diamond Industry," H. J. Van Der Munnik, *Commercial Holland*, August, 1920, pp. 28–31. Sent by Coldwell S. Johnston, Assistant Commercial Attaché, American Legation, The Hague, Netherlands.

[2] The number containing Mr. Van der Munnik's important article on the Dutch diamond industry has been kindly sent to us by Mr. Coldwell S. Johnston, Acting Commercial Attaché of the American Legation at The Hague, Netherlands.

tion of the diamonds, but his efforts were unsuccessful. When, however, during the World War, the danger became apparent that Amsterdam's supply of rough diamonds might be cut off, a group of persons subscribed a fund of 800,000 florins to finance investigation of the region by the mining engineer Loor, dry ground being chosen this time. The results, though essentially negative, were not altogether unfavorable. Later, explorations were undertaken, under Government auspices, by the mining engineer Kroll. His report only gives the opinion that in the long run something of value might be found, perhaps *coal*, if not diamonds. All this does not cast a very rosy light over the prospects of diamond mining on an extensive scale in Borneo, and the fact that since the war the normal sources of supply flow freely to Amsterdam as before, has acted as a check upon the development of Borneo's diamond fields. As we have already noted, a new danger has sprung up in the attempt to establish extensive diamond-cutting works in Great Britain, and also in South Africa, in the former land with the object of providing a suitable and profitable industry for soldiers who had lost their lower limbs. But, in spite of certain good results that have been obtained in this direction, it seems doubtful that a really dangerous competition for the trained army of Dutch diamond-cutters is to be feared from these enterprises.

Brazil.—The diamond prospects of Brazil have recently attracted the attention of representatives of financial houses in Europe, America and South Africa, with the result that several properties where the conditions for diamond mining seemed good have been acquired by them. Among these is an extensive tract of alluvial deposits along the Jequitinhonha River, and a company floated in London has installed machinery and has been testing the virgin gravels, which lie beneath a heavy overburden. Some diamonds of good quality have been found which, with the nuggets of gold found in association, have served to give a relatively high value per cubic yard to the material excavated. These encouraging results have favored registrations in London to secure additional capital so as to insure a scientific working of the deposits.

More important than these alluvials is the success that has been obtained by a methodical testing of the Boa Vista mine near Diamantina, State of Minas Geraes. This work has been done by a company formed in Rio de Janeiro, and a reliable authority has pronounced the results to be of a gratifying nature. This Boa Vista mine, in the Serra do Espinhaço, belongs to the class of "high level" occurrences, as it lies about 4000 ft. above sea-level. It has been given a good test under the direction of a well-known South African geologist, and is considered to be payable. It covers approximately an area equaling 15,000 of the South African claims, that is to say about 1,500,000 sq. yd. Situated as it is

upon an eminence, and enjoying an abundant supply of water, the hydraulicking method can be used for working it, and thus make it the most economically worked mine anywhere in the world. The quality of the diamonds is excellent, there being not more than 2 per cent. of inferior stones to the parcel. There are several other diamond mines in the Diamantina district, indeed one of these is reported to be even richer than the Boa Vista, though of much more modest dimensions.

However, it is stated that there are no indications of a true diamond "pipe" resembling those that have been found in South Africa.

British Guiana.—Here diamond mining has been prosecuted with considerable success in recent years. In addition to a renewed exploitation of the Cuyuni River around Dukwari, several small expeditions have operated on the Potaro River at points higher up the stream than those worked in former years. In this latter region the exploiters found stones of better size and shape than had before been extracted, the diamonds equaling those of the Mazaruni district. They came from a greater depth, and certain indications point to a permanence of good results that would attract capital to this region. A new area has also been located recently on the Mazaruni and its tributary the Puruni, and has been actively worked; a number of stones ranging in weight from 4 to 8½ carats have been found. The output of British Guiana for the year ending June 30, 1920, is thus given:[1]

District.	No. of Stones.	Weight in Carats.
Mazaruni	75,909	14,944
Puruni	4,240	1,045¾
Cuyuni	15,702	1,920
Potaro	2,740	249¾
	98,591	18,159½

This gives an average weight of 0.184 carat, very nearly the same as that of the diamonds mined in the previous year, and much higher than the average of all those recovered from Apr. 1, 1900, to June 30, 1920, which was only 0.105 carat. The totals for this period of twenty years are as follows:

Number of diamonds, 1,747,618
Weight in carats, 183,630$\frac{5}{32}$

There was an increased production of diamonds in British Guiana during the 10 months period, Jan. 1–Oct. 31, 1920, when there was exported 19,175 carats of diamonds, valued at $805,593, an average of $42 per carat, as against 12,115 carats, worth $248,350, for the corresponding period of 1919, an average of only a trifle over $20 per carat. Of these Guiana diamonds the greater part go to England, but few being sent to the United States. In view of the small average size of the stones the

[1] Thirteenth Annual Report of Institute of Mines and Forests, British Guiana, 1919–1920.

relatively high price for 1920 is noteworthy. It has been stated that a New York firm has opened an office in Georgetown for the purpose of buying diamonds and operating diamond-cutting works there.

In the last half of 1920, the diamond production must have increased very rapidly, as the Commissioner of Lands and Mines reports that during the entire year 234,456 stones were found, having an aggregate weight of 39,362½ carats. Uncorrected export figures for the last two years are as follows:

	Number of Carats.	Value.
1919	15,573	£ 83,650
1920	27,800	200,266

It is noted that, judging from these figures, there must have remained about 12,000 carats unexported. About two-thirds of the 1920 production came from the Mazaruni district, while from the more recently exploited Puruni district as many as 44,134 stones weighing 7,254½ carats were secured in the last quarter of 1920. In view of the fact that the mining operations in British Guiana are prosecuted in a thickly wooded tropical forest and by black prospectors, ignorant of geology and depending upon such knowledge as they can pick up from fellow-workers, the results may be regarded as quite satisfactory under present conditions. The following brief description is given of the modus operandi:

"The gravel or pay dirt is puddled and gradually forced through a series of iron screens, the holes in which begin with a half-inch in the first screen, and are gradually reduced to one-eighteenth of an inch in the last one. The fine gravel which has passed through this last screen is collected

PRODUCTION OF DIAMONDS IN BRITISH GUIANA

Year.	Number of Diamonds.	Weight in Carats.	Average Weight in Thousandths of a Carat.
1901–1902	91,206	8,227	90
1902–1903	163,680	10,447	64
1903–1904	164,315	10,742	65
1904–1905	175,400	10,619	60
1905–1906	65,752	4,097	62
1906–1907	65,903	4,661	71
1907–1908	29,007	2,122	73
1908–1909	63,161	5,618	88
1909–1910	85,537	7,181	84
1910–1911	26,467	3,035	115
1911–1912	78,683	7,648	97
1912–1913	62,624	6,099	97
1913–1914	93,752	11,110	119
1914–1915	100,522	13,716	136
Apr. to Dec., 1915	19,461	3,678	184
1916	93,782	16,409	175
1917	102,957	17,908	174
1918	77,819	14,196	183
1919	84,466	16,706	197
1920	234,456	39,362	168

and thrown on a large iron plate, on a table, and being spread out, it is then carefully searched through for the diamonds, which are easily recognizable by their brilliant lustre and shape."

After patiently accumulating their finds, the miners troop down to Georgetown in the course of the weeks preceding the Christmas holidays and realize upon their precious wares. For this reason the most favorable report of the Commission of Lands and Mines is that for the quarter in which are included these holiday transactions.[1]

Congo.—While development work was pushed in 1920 in the Kasai diamond fields of the Belgian Congo, no attempt was made to increase the diamond output. The Forminière company produced about 215,000 carats of diamonds and also notably increased its stock of diamantiferous gravel. Another work that is being pushed by this company is the delimitation of the great tract of diamond-bearing land owned by it. Besides this, the company has directed the diamond exploitation work of five associated companies operating in the Belgian Congo. A production of approximately 100,000 carats of diamonds is reported from a sister company, known as "Diamang," which operates in Angola, Portuguese West Africa.[2]

DIAMOND OUTPUT OF THE BELGIAN CONGO

	Carats.		Carats.
1915	48,995	1918	164,420
1916	53,940	1919	275,000
1917	100,000		

The announcement has been made that the Société Forestière et Minière du Congo ("Forminière") has been granted the right to develop the diamond deposits stated to have been discovered in the region where the company has already secured a mining concession for gold, magnesite and hematite. The deposits are said to cover an area of 20,000 hectares (nearly 50,000 acres) in the vicinity of the Aruwimi, Tele and Dinda rivers.

The Belgian Minister of Colonies has made arrangements with one of the diamond merchants of Antwerp to open an office in Antwerp for the sale of Congo diamonds. In this way the agents of the "Forminière" will be able to sell its diamonds directly to the Antwerp cutters. However, it is stated that some objection has been made by the "Union Diamantaire de Belgique" against the introduction of any more rough diamonds into the market so long as the present depression of the diamond industry continues.[3]

Southwest Africa.—It appears that under the five or six years of German control, the Southwest African diamond fields produced about

[1] *Watchmaker, Jeweler, Silversmith and Optician*, May, 1921.
[2] Sidney Ball, "Belgian Congo," *Eng. Min. Jour.*, Jan. 22, 1921.
[3] Consul George S. Messersmith, Antwerp, *Comm. Rept.*, Feb. 17, 1921

5,400,000 carats of diamonds, having a value of nearly $45,000,000. Of this the year 1913, the last of German exploitation, furnished 1,470,000 carats worth $15,000,000, the maximum production. Of course the war put a stop to this industry for quite a time, but nevertheless after British occupation of the territory had been established, operations were resumed on a small scale, so that in 1918 there was an output of 372,139 carats valued at $3,645,000. The recent amalgamation of the old companies of this region carried on under the initiation of the Anglo-American Corporation, Ltd., resulted in grouping the nine leading German diamond-mining companies into a new Consolidated Diamond Mines of Southwest Africa, Ltd., registered at Capetown. As a purchase consideration the German companies received £3,675,000, of which £1,900,000 was in cash and £1,775,000 in stock of the new company; they are also to have four of the nine directors on the board of the new organization.[1]

The exceptionally high price of £8 4s. 4d. (something less than $33 at present exchange) has been taken as the basic price of the 1920 output from the old German Southwest Africa. It now appears that this was based on parcels containing about 80 per cent. of Pomona goods, and the diamonds from the Pomona region average much higher in weight than those from other parts of these Southwest African diamond fields. Hence it is assumed that a truer average for the product would be £7 or £7 10s. ($28 or $30).[2] Indeed the price should probably be set even something lower than this, for the difference in favor of the Pomona diamonds is quite considerable.

The company formed in 1919 to dredge the sea-bottom between Possession Island and the shore of the Southwest African Protectorate realized at the outset an astonishingly high price for the shares, which were for a time quoted at a premium of about 800 per cent. However, the steam-dredge which was bought was destroyed by an accident, and no further attempt was made to carry on operations. In view of the fact that there was no sound reason for supposing that the submarine gravels contained diamonds in paying quantities, the fact that the needed capital could be raised for this undertaking is regarded as somewhat surprising. We cannot safely assume that the gravels of the sea-bottom are equally rich with the diamantiferous sands which have been worked on land, for admitting that the latter had originally lain under the sea before the uplift of the continent, their present state is due to long concentration by wind action, which has carried away billions of tons of sand, leaving the heavier diamonds and pebbles behind. Admitting this, the sands beneath the sea must be very much poorer in diamonds.[3]

[1] *Min. Jour.*, July 17, 1920.
[2] Communicated by P. A. Wagner in letter dated Pretoria, Aug. 1, 1920.
[3] Communicated by Mr. A. S. Harger of South Africa.

Union of South Africa.—The estimated value of the diamonds produced in the Union of South Africa during 1920 constituted a record for the industry. The value of the mined, alluvial, and débris-washed diamonds totaled for the year the sum of £14,762,899. The bulk of this amount, or £12,289,602, came from the mines, £2,441,440 from alluvial mining, and £31,857 from débris washings. The previous record year was 1919, the output being valued at £11,734,495. Prior to 1918 the high mark was 1913, when diamonds were produced to the value of £11,389,807.

The past year's output aggregated 2,545,017.47 carats, of which 2,312,436.55 came from regular mines and 221,460.17 from alluvial mining; 11,120.75 carats were recovered from débris washings. It is to be noticed that production in the past six years has been practically constant, outside of 1915 which was an abnormal year; 1917 was the high mark in this period with 2,902,416.51 carats, and 1916 the lowest with 2,346,330.21. In the last three years production has fluctuated approximately by only 50,000 carats. The year 1910 is still the record by volume for the industry, 5,456,558 carats being taken from the earth in that year.[1]

While production value constituted a record, the sales of diamonds fell below the total of 1919 by £3,411,257. This decrease is accounted for by the large drop in the volume of sales, which were only 1,765,993 carats as compared with 1919 sales of 2,648,931 carats. The sales total would have been even less in value except for the increase in the price realized, which was 117s. in 1920 against the 1919 figure of 101s. per carat. This high figure reflects the effect of abnormal conditions on prices, as the price realized per carat in 1917 was 51s. 1d. and in 1918 was 54s. 9d. That these high prices stimulated production is evident in that there were 19 mines producing in the Union in 1920, compared with 16 in 1918 and 11 in 1917.

The production within the Union is divided, in order of importance, among the Cape, the Transvaal, and the Orange Free State. The Cape contributed 1,364,706.25 carats, of which 1,258,129 were from the Kimberley mines. The Transvaal production was 905,297.05 carats, practically the whole of the 782,557.30 mine diamonds being the output of one mine. The share of the Orange Free State was 275,014.17, of which 269,178 carats were from the nine mines in that district.

The total diamond production of South Africa for the years 1913–1920 is given below.[4] The variations in yield—in 1915 but very few diamonds were recovered—and those in price, are well worth attention:

[1] Trade Commissioner P. S. Stevenson, Johannesburg, *Comm. Rept.*, June 2, 1921.
[4] *So. Afr. Min. Eng. Jour.*, Mar. 15, 1921.

PRODUCTION OF DIAMONDS IN SOUTH AFRICA

Year.	Production from Mines.			Alluvial Diamonds.		
	Carats.	Estimated Value.	Value per Carat.	Carats.	Estimated Value.	Value per Carat.
1913	4,944,946	£10,254,203	41s. 6d.	206,049	£1,120,227	108s. 9d.
1914	2,653,089	4,906,342	37s. 0d.	143,924	576,729	80s. 2d.
1915	2,131	3,887	36s. 6d.	97,678	392,196	80s. 4d.
1916	2,170,348	4,769,479	43s. 11d.	167,620	948,571	113s. 2d.
1917	2,710,041	6,659,721	49s. 2d.	182,992	1,041,776	113s. 10d.
1918	2,385,361	6,137,283	51s. 5d.	143,438	964,574	134s. 6d.
1919	2,366,744	8,960,614	75s. 9d.	209,589	2,740,548	261s. 6d.
1920	2,312,436	12,289,602	106s. 3d.	221,460	2,441,440	220s. 6d.

The total sales for the above years are given as follows, a part of the diamonds sold having been mined in the previous year:

	Carats.	Value.	Value Per Carat.
1913	5,537,820	£12,088,983	43s. 8d.
1914	3,363,568	6,758,544	40s. 2d.
1915	551,951	1,459,597	52s. 11d.
1916	2,291,956	5,227,777	45s. 7d.
1917	2,416,209	6,170,906	51s. 1d.
1918	2,641,932	7,232,744	54s. 9d.
1919	2,648,931	13,379,662	101s. 0d.
1920	1,765,554	10,163,941	115s. 2d.

The production of alluvial diamonds in South Africa for 1920 is officially reported as follows:[1]

Province and District.	Carats.	Value.	Value Per Carat.
Transvaal:			
Pretoria District	122,740	£1,209,442	197s. 1d.
Klerksdorp			
Cape:			
Kimberley	8,568	119,335	278s. 7d.
Barkly West	57,457	698,529	243s. 2d.
Taungs	18,926	232,773	246s. 0d.
Herbert	7,918	93,616	236s. 6d.
Hoy	¼	2	.....
Prieska	14	30	.....
Vryburg	¾	7	.....
Orange Free State:			
Fauresmith	1	3	.....
Boshop	926	12,863	277s. 11d.
Winburg	42	162	.....
Rouxville	4,856	74,525	306s. 11d.
Vredefort	8	137	.....
Hoopstad	2	15	.....
Ficksburg	2	1	.....
Total	221,461	£2,441,440	220s. 6d.

The depression of the diamond trade caused, by the beginning of 1921, a cessation of mining operations in all the smaller South African mines, such as the Frank Smith, the Roberts Victor, the Eland, Blaauwbosch,

[1] *So. Afr. Min. Eng. Jour.*, Mar. 12, 1921.

Theron, Postmas, Makgangene, and others, while at the Koffyfontein and the Jagersfontein mines work has ceased, and the Kimberley and De Beers mines remain closed down. At the other mines of the De Beers group (Wesselton, Bultfontein and Dutoitspan) and at the great Premier mine in the Transvaal, production has been curtailed. It is conjectured that even in case of a revival in the trade some of the smaller mines above noted may remain shut down, as they were barely profitable even with diamonds at their highest figure. In the case of some of the open mines, where the treacherous nature of their walls has made it necessary to resort to underground mining, in place of open-cut working, the increased cost of raising the material will render mining unprofitable. The alluvial diggers are in a much worse plight, as far too many were induced to come to the diggings on account of the extraordinary prices secured at the height of the diamond market. During 1919 it is said that 13,000 white men and 100,000 natives were engaged in this work, and most of them are now deprived of all means of livelihood, so that Government assistance on a very extensive scale must be initiated to save a good part of them from serious privation. Of the general situation Mr. A. S. Harger writes:

> The débâcle in the diamond trade will doubtless cause a healthy revolution in the diamond industry by shaking out many of the "mushroom" concerns which have been riding on the backs of the great Diamond Syndicate, whose business initiative has steadied the diamond market for many years past. It will also probably crush the life out of the alluvial industry, for two important reasons: (1) The diggers' life is always an uncertainty, and it is only when diamonds are high in price that the majority earn a fair living. A crisis like the present one ruthlessly forces him to dispose of his equipment, if he can find a buyer, and seek pastures new. In the present case he will fail to find a buyer and will consequently (in the majority of cases) have to depart from his claim in a state of sad impecuniosity. He will probably be forced by ensuing circumstances to relinquish digging for good. (2) During the past 40 years the richer alluvials of the Vaal River have nearly all been worked out; and during the past 12 years many areas in southwestern Transvaal (which helped so much to swell the output of river stones) have been rapidly and completely exhausted. During the prosperous year 1919 it had already become a very difficult matter for the digger to find a claim which might be deemed "safe" to peg, as many learned to their cost. The whole countryside has for some years past been closely prospected by hundreds of diggers looking for new payable areas without success. In other words the limits of the diamantiferous gravels are pretty well known, and the payable patches awaiting exploitation are of very small extent. It is likewise highly improbable that new payable mines will be found for many years to come in South Africa, as prospecting far and wide has not indicated anything of promise. The recently discovered mines near Postmasberg, in Griqualand West, are small and poor, and therefore not to be feared as "producers." These factors, though disappointing to the individual prospector and company promoter, will have a gratifying bearing on the future of the diamond market, for the simple reason that they point to a much diminished output during the normal times which are bound to return with an improvement in world conditions.

The Thirty-second Annual Report of the De Beers Consolidated Mines, Ltd., for the year ending June 30, 1920, makes an exceedingly favorable showing. The Profit and Loss Account shows the immense sum of £6,761,840 credited to Diamond Account, as compared with £5,849,552 in the previous year. Interest, dividends, net revenue from rents, sundry receipts, transfer fees and profits realized on investments increased the income to £6,997,900. From this had to be deducted £1,991,258 for mining expenses, £442,305 for charges, £96,392 for interest on capital of leased companies, £69,917 for interest on debentures, £78,803 for sinking fund on debentures, £32,379 for expenditure consequent to the war, and £72,180 for sundry other small items. Thus there was left £4,264,666 to be transferred to Appropriation Account; of this account the income tax of South Africa absorbed £439,550, and the Reserve for Stabiliment of the Diamond Trade received £382,069. The preference dividends were 20s. per share, or £800,000, less dividend tax of £60,000, making £740,000, while the deferred shares received 60s. per share, or £3,000,000. Diamonds unsold at date are valued at £354,244, and there remains a balance of £237,830 16s. 11d. carried to the next balance sheet. The apparent discrepancy in the data as here given arises from the larger totals for previous balance and for unsold diamonds as compared with those for the current year. The dividends were equivalent to 40 per cent. on the preferred shares, and 120 per cent. on the deferred shares.

At the general meeting of the stockholders of the De Beers company, Dec. 10, 1920, the chairman announced the abandonment of the old flooring system in favor of the direct-treatment system. The reasons for this change are given by him as follows:

> Hitherto in the treatment of our blue ground we have followed the old flooring system, under which the ground was deposited on cleaned spaces and left to weather for periods of from 9 to 18 months, at the end of which time it had pulverized and was ready for treatment at the washing machine. This system involved the carrying of enormous stocks of blue ground with, of course, the locking up of much capital.
>
> These disadvantages do not occur in a direct-treatment system, and for some years its adoption has been under consideration, but for various reasons no decision was arrived at until July last. It was felt that a decision should not be delayed, seeing that with the increasing depths of the mines our blue ground was becoming harder and harder, and therefore required longer time to pulverize, which in turn meant the locking up of a much larger amount of capital. The flooring system entails the carrying of a stock of blue ground of about 10,000,000 loads, but with the direct-treatment system the reserve need not exceed 3,000,000 loads, which would be ample to meet our washing requirements during the longest time the mines could be closed down through any disaster.
>
> In anticipation of direct treatment, and in view of the large stock of diamonds we hold, it was decided to reduce all operations by about 50 per cent. as from Sept. 1,

1920, and to deposit the output from the mines on dumps in readiness for direct treatment.

The cost of production per load of blue ground, the value per load, and the profit per load in the three mines of the De Beers group that were worked in 1918, 1919 and 1920 were as follows, according to data derived from the reports of the company.

	Cost of Production per Load.	Value per Load.	Profit per Load.
1918.			
Wesselton	4s. 10.94d.	14s. 9.59d.	3s. 10.65d.
Bultfontein	3s. 11.61d.	17s. 5.16d.	13s. 5.55d.
Dutoitspan	3s. 8.8d.	20s. 7.42d.	16s. 10.62d.
1919.			
Wesselton	6s. 7.19d.	16s. 9.55d.	10s. 2.36d.
Bultfontein	5s. 6.39d.	19s. 8.03d.	14s. 1.64d.
Dutoitspan	4s. 9.39d.	23s. 9.22d.	18s. 11.83d.
1920.			
Wesselton	8s. 4.97d.	28s. 7.02d.	20s. 2.05d.
Bultfontein	7s. 3.99d.	29s. 9.94d.	22s. 5.95d.
Dutoitspan	6s. 8.48d.	35s. 4.70d.	28s. 8.22d.

In each case the greatly increased value of the diamond in 1920 far exceeds the trifling increase in cost of production.

The statistics of working and production in the De Beers group of mines for the years 1916 to 1920 are as follows:

DE BEERS AND KIMBERLEY MINES

	Loads of Blue Ground Hoisted.	Loads of Blue Ground Washed.	Carats of Diamonds Found.	Selling Value per Carat.
1915–1916	None	None	38½	Not Stated
1916–1917	None	None	41	Not Stated
1917–1918	None	None	315¾	Not Stated
1918–1919	None	None	241¾	Not Stated
1919–1920	None	None	242	Not Stated
WESSELTON MINE				
1915–1916	43,586	885,334	227,914¼	44s. 2.31d.
1916–1917	1,814,393	1,669,104	445,665¾	53s. 9.27d.
1917–1918	2,065,620	1,805,436	487,828½	54s. 9.76d.
1918–1919	1,035,311	1,657,146	403,039¾	69s. 11.79d.
1919–1920	1,927,178	1,646,895	401,531½	119s. 1.25d.

BULTFONTEIN MINE

1915–1916	60,997	864,052	342,676¼	39s. 11.09d.
1916–1917	2,092,267	1,761,756	675,401¾	46s. 11.00d.
1917–1918	2,328,615	1,859,531	646,927¾	49s. 9.62d.
1918–1919	1,262,942	1,629,198	507,858¾	63s. 5.38d.
1919–1920	2,021,026	2,251,257	663,419¾	102s. 10.29d.

DUTOITSPAN MINE

1915–1916	None	108,597	20,740¼	91s. 0.26d.
1916–1917	135,650	1,927,335	377,571¼	106s. 11.93d.
1917–1918	2,200,000	2,178,132	422,657¾	108s. 6.22d.
1918–1919	1,389,883	1,066,465	180,983	139s. 9.77d.
1919–1920	1,796,573	1,892,558	305,587	221s. 2.36d.

GRAND TOTALS FOR ALL MINES

1913–1914	7,166,829	6,641,398	1,903,621¼
1914–1915	738,472	693,822	188,136
1915–1916	104,583	1,857,983	591,369½
1916–1917	4,042,310	5,358,195	1,498,679¾
1917–1918	6,595,078	5,843,099	1,557,729¾
1918–1919	3,688,136	4,352,809	1,092,123¼
1919–1920	5,744,777	5,790,710	1,370,780¾
1913–1920	28,080,185	30,338,016	8,202,439¾

The number of loads of blue ground remaining on the floors of the De Beers mines at the close of the fiscal years, and the average number of carats found in the blue ground washed in the year 1919–1920, are thus given:

DE BEERS MINE

	Carats per 100 Loads.	Value per Load.	Loads of Blue Ground on the Floor at Close of Year.
1915–1916	.....	.....	48,396
1916–1917	.....	.....	48,396
1917–1918	.....	.....	48,396
1918–1919	.....	.....	48,396
1919–1920	.....	.....	48,396

WESSELTON MINE

1915–1916	26	11s. 5.8d.	2,607,097
1916–1917	27	14s. 6.22d.	2,752,386
1917–1918	27	14s. 9.59d.	3,012,570
1918–1919	24	16s. 9.55d.	2,390,735
1919–1920	24	28s. 7.02d.	2,671,018

BULTFONTEIN MINE

1915–1916	40	15s. 11.6d.	2,335,266
1916–1917	38	17s. 9.94d.	2,665,777
1917–1918	35	17s. 5.16d.	3,134,861
1918–1919	31	19s. 8.03d.	2,768,605
1919–1920	29	29s. 9.94d.	2,538,374

DUTOITSPAN MINE

1915–1916	19	17s. 3.48d.	4,233,303
1916–1917	19	20s. 3.94d.	2,411,618
1917–1918	19	20s. 9.22d.	2,434,329
1918–1919	17	23s. 9.22d.	2,757,747
1919–1920	16	35s. 4.70d.	2,661,762

BLUE GROUND IN SIGHT, VALUE IN POUNDS STERLING BASED ON LOAD-VALUE FOR 1920

	Number of Loads.	Value.[1]
De Beers, above 2040 ft.-level	2,750,000	£3,930,437
Kimberley, above 3250 ft.-level	2,000,000	2,858,500
Wesselton, above 980 ft.-level	8,500,000	12,148,625
Bultfontein, above 1000 ft.-level	5,000,000	7,448.750
Dutoitspan, above 750 ft.-level	10,500,000	18,580,625
Total	28,750,000	44,966,937

[1] De Beers and Kimberley estimated at Wesselton average. With exchange at one dollar below par, this would be $173,864,652.

The number of loads below the levels above noted have been estimated as follows:

Wesselton, between 980-and 1150-ft. level	22,000,000
Bultfontein, between 1000-and 1600-ft. level	22,000,000
Dutoitspan, between 750-and 1300-ft. level	25,000,000
Total	69,000,000

The accumulated stock of blue ground on the floors of the mines and its value, computed according to the diamond-value per load in 1920, is as follows:

Mine.	Number of Loads.	Value.
Wesselton	2,671,018	£3,817,552
Bultfontein	2,538,374	3,785,773
Dutoitspan	2,661,762	4,610,210
Total	7,871,154	£12,213,535

Even counting the exchange value of the pound sterling as one dollar below par, this would mean $47,223,633 as the value of the blue ground on hand June 30, 1920.

After remarking that of the De Beers mines, the Dutoitspan produces the greatest number of stones over 10 carats' weight, while the neighboring mine, Bultfontein, has the smallest number of large stones, Mr. J. R. Sutton pronounces to be erroneous the often cited opinion that the diamond yield diminishes with the increase of the depth, for he finds instead a slight increase since 1905. Nevertheless, the proportion of brown stones and of cleavage fragments increases. As to the latter, he favors the view that the breaking of the crystal has been due in many cases to the unequal thermal expansion of the diamond and of enclosed crystals, of zircon, garnet, ilmenite, etc.[1]

The operation of the Premier mine during the year ending Oct. 31, 1920, resulted even more favorably than in the immediately preceding year, for the account showed a balance of £1,332,333, the Government share (60 per cent.) being £799,400, while £532,933 was left for the stockholders. This made it possible to declare two dividends, each of 6s. 3d. per share, on the preference shares, and two dividends, one of 15s. per share and the other of 12s. 6d. per share on the deferred shares.

[1] J. R. Sutton, "Kimberley Diamonds; Especially Cleavage Diamonds," *Trans. Roy. Soc. So. Afr.* 1918, Vol. 7, pp. 65–96.

The total number of loads washed was 4,660,498, from which were recovered 820,564 carats of diamonds, an average of 0.176 per load. Although this was the lowest average yield so far reported in the Premier, the decrease was in the first half-year, the last six months showing a slight increase in the average over the figures for the previous year. As to the working costs, there was an increase of about 3d. due to a 20-per cent. increase in wages to the European employees and a high wage paid to the native workers, besides the increased cost of mining supplies. The material was taken from above the 410-ft. level, where mining was carried on practically over the entire area. Above this level there still remain about 27,000,000 loads of blue ground. The 460-ft. level has been developed at the south end of the mines, where the total quantity of blue ground available is estimated at 41,000,000 loads. To facilitate future mining operations, a tunnel measuring 11 by 7 ft. has been run through a bar of floating reef, so as to furnish a haulage way between the 410-ft. level on the north side of the mine and the chief onsetting station. This will render it no longer necessary to preserve a large bench of diamantiferous ground on each level as a support for the auxiliary mechanical haulage in the northern division of the mine.[1]

DIAMOND OUTPUT OF PREMIER MINE

Year Ended Oct. 31.	No. of Loads Washed.	No. of Carats Found.	Value of Diamonds.	Yield Per Load in Carats.	Value Per Carat.	Value Per Load.	Cost of Production Per Load.	Profit Per Load.
			£		s. d.	s. d.	s. d.	s. d.
1903	76,931	99,208¼	137,435	1.290	27 8.50	35 6.70	4 7.20	30 11.50
1904	939,265	749,653½	866,030	0.798	23 1.20	18 5.30	2 7.62	15 9.68
1905	1,388,071	845,652	994,687	0.609	23 6.29	14 3.98	3 3.44	11 0.55
1906	2,988,471	899,746	1,277,740	0.301	28 4.82	8 6.61	3 5.71	5 0.90
1907	6,538,669	1,889,986¼	1,702,631	0.290	18 0.20	5 2.49	2 4.14	2 10.35
1908	8,058,844	2,078,825¼	1,536,720	0.258	14 9.40	3 9.75	1 10.24	1 11.51
1909	7,517,793	1,872,136½	1,172,379	0.249	12 6.29	3 1.43	1 11.42	1 2.01
1910	9,331,882	2,145,832¾	1,496,641	0.230	13 11.39	3 2.49	2 0.56	1 1.93
1911	8,325,272	1,774,206	1,433,971	0.213	16 1.97	3 5.34	2 2.02	1 3.32
1912	9,707,098	1,992,474	2,004,943	0.205	20 1.50	4 1.57	2 4.79	1 8.78
1913	10,434,680	2,107,983	2,336,828	0.202	22 2.05	4 5.74	2 6.67	1 11.07
1914	7,683,943	1,417,755	1,259,643	0.185	17 9.23	3 3.34	2 5.89	9.45
1915	Mining operations suspended.							
1916	1,572,521	419,947	475,856	0.267	22 7.95	6 0.63	2 7.62	3 5.01
1917	4,928,629	906,341	1,198,923	0.184	26 5.48	410.38	2 2.68	2 7.60
1918	4,805,851	851,573	1,203,904	0.177	28 3.29	5 0.12	2 2.89	2 9.73
1919	4,529,261	814,577	1,961,259	0.180	48 1.84	8 7.92	2 10.68	5 9.24
1920	4,660,498	820,564	2,098,483	0.176	51 1.80	9 0.03	3 1.70	5 10.33

This gives the following totals for the 17 years:

Number of loads washed	93,487,679
Carats of diamonds found	21,686,461
Value of diamonds	£23,158,072

While, as we see, the returns for 1919–1920 were very satisfactory, the chairman, at the annual meeting, freely admitted that the stockholders could not look forward to as good results in the coming year, owing to the great falling off in the demand for diamonds. He then

[1] *So. Afr. Min. Eng. Jour.*, Feb. 12 and Mar. 5, 1920.

warned his hearers that the year 1920–1921 promised to be "a very lean one in profits," but he consoled them with the consideration that the diamond industry had often had such setbacks, and had always given proof of the possession of extraordinary recuperative power.

The Postmasburg diamond region, which has attracted so much attention of late, is approximately 40 miles from Griqua Town, and lies about 125 miles west of Kimberley. There is communication by a fairly good road to Kimberley, the nearest railroad station, and a motor makes bi-weekly trips between it and Postmasburg, passing through Griqua Town. The chief geological features of the field are a dolomitic limestone covering, basal beds of the Griqualand series, and doleritic dikes which traverse the limestone. A line of igneous intrusion seems to traverse the country for many miles from north to south. It is near this fracture line that the kimberlite occurrences are noted, and the Emerald Diamonds, Ltd., a company capitalized at £500,000, has secured options on over 40 farms along this line. This company is closely associated with the Victory Diamonds, Ltd., which holds very promising diamond fields in a large concession situated in the Gordania district, and also at Rietfontein in the Kuruman district, and at Paardeberg West, near Kimberley.[1]

In the Postmasburg region several productive "pipes" have been discovered during the past 2 or 3 years. The earliest discovery was the Makganyene pipe, 45 miles north-northwest of Postmasburg. It has an area of 240 claims, but the yield is low, being only from 2¾ to 3 carats per 100 loads, and though the stones are of very fine quality, this yield is insufficient to make the mining very profitable. Somewhat better results were realized in the West End pipe, found in 1919, and having a yield of 5 carats to every 100 loads. Of two pipes located by the Postmasburg Diamond Prospect Ltd. near the West End pipe above mentioned, one has failed to produce results, while the other seems to be diamantiferous in a small degree.[2]

The company has erected a direct treatment plant with a capacity of 1000 loads per diem. It is located 1600 ft. east of the mine, and is equipped with crushers, rolls and jigs. The final eliminating jigs deliver to a tube mill which in turn delivers to self-greasing tables. For the present, the plan is only to treat 500 loads per shift.[3]

At the seventh general meeting of the South African Corporation in December, 1920, the chairman reported a profit for the year of £131,306, an increase of £86,934 over the profits reported in the previous year. These earnings were realized on a capital of £100,000 for the first six

[1] "The Postmasburg Diamond Field," *So. Afr. Min. Eng. Jour.*, Apr. 10, 1920.
[2] Communicated by P. A. Wagner, of Pretoria, in letter dated Aug. 28, 1920.
[3] Letter of Dr. P. A. Wagner, Pretoria, Jan. 8, 1921.

months of the year, and £300,000 for the remaining six months. The chairman hoped that the Government would decide to repeal the excess profits duty, but owing to the uncertainty of this relief it had been determined to declare a dividend of only 25 per cent. per annum for the six months ending Dec. 31, 1920. He stated that, by the coming June, the former dividend of 50 per cent. per annum would be resumed.[1]

The last statement of the New Jagersfontein Mining and Exploration Co., Ltd., shows that during the year 1919–1920 £1,257,678 was realized on diamonds, an increase of over £500,000 compared with 1918–1919. This made possible dividend payments of £531,350, while £100,000 was transferred to General Reserve Fund and £87,148 was carried forward as balance, after other expenses had been deducted. At the meeting of Aug. 24, 1920, in Kimberley, the deputy-chairman, Mr. F. Hirschhorn, declared that, at the conference of the four great diamond-producing companies, an agreement had been reached to control the quantity of diamonds put on the market, thus stabilizing prices.[2]

The yield of the Frank Smith diamond mine, where mining operations were resumed in December, 1920, after an interruption during the war, is said to be better than it was some years ago. The average weight of the diamond material in a hundred loads is reported to be 2.8 carats, and it has been computed that a yield of 2¼ carats covers cost of production. It is believed that even this small margin of profit will not prove unsatisfactory, in view of the large capacity of the plant and the moderate capitalization of the company.[3] However, these favorable prognostics have not been fulfilled, owing to the decreased demand.

A new South African company is the Victory Diamonds, Ltd., with a capital of £60,000. This company has secured the farm Mahura Mathla, on the Kaap Plateau, where some fine alluvial diamonds were found a few years since. Another acquisition of this company is the Paardeberg West mine in the Kimberley district. This mine was worked in 1905 and 1906 and it is now proposed to reopen it soon. The resumption of activity here and in other old workings is a result of the high prices obtainable for diamonds recently. Another old mine at which working has been resumed is one of those of the Montrose company, the pipe situated near Rayton, east of Pretoria.[4] Of course the resumption of work, or the continuance of work, in all these mines depends upon future developments in the diamond market.

The 7000 enthusiastic diamond diggers who, in March, 1920, rushed to the Thlaping farm in the Hart's River valley, which forms part of the Taung's Reserve, were not overwell rewarded for their expedition. It

[1] *So. Afr. Min. Eng. Jour.*, Dec. 11, 1920.
[2] *Manufacturing Jeweler*, Sept. 23, 1920.
[3] *So. Afr. Min. Eng. Jour.*, Jan. 22, 1921.
[4] Communicated by P. A. Wagner, of Pretoria, in letter dated Aug. 28, 1920

has been already noted in the previous report that the proclamation of this district was opposed by the native chief, but his opposition was overruled. From Mar. 25 to the end of June, 1920, the production was 7207 carats, valued at £113,590, equivalent to nearly $445,000 counting the pound sterling at $3.90. This gives an approximate value per carat of more than $55, indicating that a good number of large stones were found, although the returns to most of the diggers were small. The gravels in which the diamonds occurred were shallow and patchy, so that before long they were practically exhausted by the great concourse of diggers. Later on, the adjoining farm, Doyle's Prospect, was proclaimed, and it is stated that fairly good results have been secured there.[1]

The alluvial diamond deposits of Rouxville, near the Orange River, in the Aliwal North district, have been successfully exploited by a company, a proof that, under certain conditions, better results can be secured by a company than by individual diggers. There appears to be good reason to believe that on the lower reaches of the Orange River, which here traverses a wild and mountainous region, valuable diamond deposits may be found. At this point, where this river constitutes the boundary between Little Namaqualand, Cape Province and the former German Southwest African Protectorate, there are on its banks immense terraces of gravels, closely resembling those of the diggings, but evidently much more highly concentrated. About 50 miles from its mouth, where the river passes out from a series of narrow cañons, within which it has been enclosed for a long distance, the terraces have developed into hills 200 or 300 ft. high, consisting of a succession of layers of gravel. In the lower strata, the gravel is bound together by lime so as to form a kind of conglomerate, and closely resembles the appearance of the very rich deposit recently found at Rouxville almost 800 miles distant. Occasional diamonds have been found here by the natives, but owing to the inaccessibility of the region no serious attempts have been made to exploit this very promising region.[2]

In view of the so often observed association of gold and diamonds, it is interesting to learn that in 1920 there were recovered from the Witwatersrand gold mines, notably the Modder B. and Van Ryn Deep, 61 carats of diamonds worth £293.[3]

Venezuela.—The finding of diamonds in Venezuela has been reported by Prof. Louis Duparc of the University of Geneva. Not long since he carried out a prospecting journey through the auriferous deposits of Callao. In the course of this trip he was able to determine that the

[1] Communicated by P. A. Wagner of Pretoria in letter dated Aug. 28, 1920.
[2] Fred E. Cornell, "The Alluvial Diamondiferous Deposits of South and South-West Africa," *Chem. News*, Mar. 4, 1921.
[3] *So. Afr. Min. Eng. Jour.*, Mar. 12, 1921.

alluvials of the Caroni River, markedly auriferous in certain places, contained almost everywhere very pretty diamonds. As a rule they were quite small, weighing less than a carat each, but occasionally some were met with having a weight of as much as two or more carats. Ordinarily they are of octahedral form, and quite strongly rolled; they are generally of fine water and of unusually white hue.[1] One might conjecture, under these circumstances, that Venezuela could become a rival of the not far distant British Guiana as a diamond producer.

Other Precious Stones

Connecticut.—A certain quantity of gem material was found in Connecticut during 1920, mostly at Strickland's Quarry, from which about $250 worth of gems was sold during the year. The material included some fine crystals of purple apatite of gem quality, considerable gem citrine quartz and smoky quartz, a blue-green tourmaline weighing 131 carats, and some beautiful beryls.[2]

Madagascar.—The most valuable of the precious stones exported from Madagascar recently have been the pink beryls (morganite), of which some exceptionally fine specimens of a salmon-rose hue have been furnished by a new vein discovered in the region of Anjanabonona. Locally these beryls sell for from 35 to 40 francs per carat, while the tourmalines from the same region bring only from 3 to 5 francs a gram (equal to 5 carats). Other semi-precious stones, such as the garnets of Fianarantsoa, Bektroks and Fort Dauphin, are disposed of at prices ranging from 100 to 500 francs the kilogram (equal to 5000 carats). Beautiful crystals of transparent orthoclase are reported from the neighborhood of Isohy. In all, semi-precious stones weighing 424 kilograms were export ed from this island in 1919.[3]

Jade

It is reported that but little fine cut jade was imported to China from Burma during 1919, and for this reason there was a considerable advance in prices. For the year the sales amounted to about $800,000. Disturbed local conditions in Canton caused a decrease in the number of cutters of jade-stones employed there to about 5000, this being only half the number usually at work in this industry. For this reason the supply of cut stones was so much restricted that but few were exported.[4]

[1] Communicated by Prof. Dupare in letter dated Geneva, May 8, 1921.
[2] Communicated by Mr. Harold T. Stearns, Dec. 7, 1920.
[3] *Le Moniteure de la Bijouterie.*
[4] Walter A. Adams, Vice-Consul in Canton, China, *Comm. Rept.*, 1921.

Moss Agate

The tree agates of Montana are found in a very narrow strip of territory running along the Yellowstone River for about 100 miles, from Billings to Glendive. Here may be picked up agates of many shades of color, from dark-red to a very light-red, often blended with brown or black. The so-called moss agate is also met with, the dark blotches seeming to fan out at the edges as would a piece of moss. Besides these there are the "fern agates," or "tree agates," perfectly transparent, and whereon are markings which seem to figure perfect little scenes, such as groves of trees, with occasionally a little strip of yellow at their bases, figuring a pool of water. Sometimes the fern-like markings appear in two colors, as, for example, when the base of the fern is black, while the upper part shades into a beautiful brown, the delicate top leaves being as perfectly formed as in the natural plant. It is stated that fine examples of such agates are becoming very rare.

Opals

The discovery of opals in Australia has greatly reduced the price of this beautiful gem. In fact, the production of Australian opals in great quantities of magnificent specimens has resulted in the practical closing down of the famous opal mines in Hungary, whence for more than two centuries most of the fine opals had been derived.

Of the Australian discoveries, the earliest dates from about 1880, when the wonderful examples of the so-called "blues" and "greens" were discovered in Queensland. Here they permeated an ironstone formation in minute veins up to an inch in width. Then came the finding of great quantities of the white varieties of precious opal in 1883, in New South Wales, at White Cliffs, where the gem was extracted from a cretaceous sandstone, sometimes named the "Desert Sandstone" in Australia. This formation contains fossil reptilian bones; mollusca (shells); belemnites (cuttlefish), and a mineral resembling galyussite. This was followed by the surprising and unique occurence, also in New South Wales, of the famous Lightning Ridge deposits, where the magnificent specimens of black or gray opals were mined, the tones emitting the most vivid flashes of red, green, yellow and purple, rendering them unique in splendor.

Not long since, in 1915, these earlier discoveries have been supplemented by the finding of opals in the desert region of South Australia—the white sandstone region—similar to the White Cliffs of New South Wales—at a point 1000 miles distant from the nearest of the

other localities, in an exceedingly arid district, barren of trees, grass and water, so that all provisions, as well as water, for man and beast must be transported thither on camel-back. Still more recently an entirely new field of white opals has been located at Tintenbar, about 50 miles south of Sydney, in New South Wales, where the gems occur in a basaltic rock, and are of the fire-opal type, resembling a number of our Nevada opals, and unfortunately sharing with them the tendency to develop cracks and fissures due to rather rapid dehydration.

Of the prevailing rock formation, L. Keith Ward, Government Geologist, writes as follows:[1]

> This upper Cretaceous formation, which is usually known by the name of Desert Sandstone, extends far beyond the limits of the country hitherto proved to be opal-bearing. The Geological map of Australia shows its extent through Queensland, New South Wales and South Australia.
>
> The opal at Stuart's Range occurs for the most part in irregular veins and patches, which are enclosed in the sandstone and claystone. . . The veins or seams are inclined at all angles, and in more than one instance a vein vertically disposed when first located has been found to gradually assume a horizontal position as it is followed downwards. The thickness of the opal seams ranges from as much as 2 in. down to an almost imperceptible streak.

The same writer reports that the maximum length of this new opal field, measured from the northwest to the southeast is about 10 miles, the maximum width nearly 2 miles, but he believes that when a water supply has been assured, further prospecting will extend the boundaries of this field. The fact that the Australian opals are found in an exceedingly dry region suggests to Mr. Ward the theory that their development is a special phase of the silicification of the upper portion of the Desert Sandstone.

Opal mining is especially suited for individual miners, as but little capital is needed. Indeed, it has been found that operations on a comparatively large scale are not remunerative, and that the best results are attained when the individual prospector owns and works his own ground.

In spite of a splendid season and an excellent market, opal mining in the far west of Queensland was as dull in 1920 as in the preceding year, when drought conditions prevailed. The only district where anything at all was done in opal mining, as far as is reported, was at Sheep Station Creek. A few specimens were obtained, some in country previously untried, but, on the whole, the result of the year's work was insignificant.[2]

Pearls

Pearl-fishing in the Concho River in Texas was actively revived in the latter part of 1920, and it is reported that some very fine pearls have been

[1] Reports forming addenda to the Records of Mines, pp. 36–44.
[2] *Queens. Govt. Min. Jour.*, Apr. 15, 1921.

found and that the yield has been quite considerable for many years past; the chief profit, however, has been from the sale of the pearl shells, which have been collected and shipped to the button manufacturers.

It is reported that the United States Bureau of Fisheries has pointed out the need for faster propagation and the prevention of unnecessary destruction of the fresh-water mussel whose shell is used by the pearl-button industry. An active campaign is said to be planned in all the large cities of the Mississippi Valley. At the same time no charge has been made that wilful destruction of the mussels has taken place. The industry is a most important one, as the annual value of the buttons and by-products reaches $5,000,000 and 8000 persons find employment in the work; the capital invested is over $3,000,000. The mussel fishing to secure supplies is prosecuted in at least 20 states in the Mississippi River basin, and the annual value of the shells amounts to $800,000, while $400,000 is realized from the pearls obtained.

A report comes by way of Paris that an unusual number of pearls, some of extraordinary size, have recently been found in pearl-oysters at certain points of the Mediterranean. In view of the theory that pearl formation is generally, or at least frequently, caused by a trematode parasite which enters the shell of the mollusk and causes an enveloping secretion of nacreous substance, the conjecture has been advanced that these Mediterranean pearls are due to an influx of such parasites through the Suez Canal from the Indian Ocean. The colors of the pearls range from light blue to pink, and they are said to be most plentiful in the waters about Tripoli, although they are also to be met with at points along the coasts of the French possessions in North Africa.

At the meeting in Paris, January 19, 1921, the Committee of the Chambre Syndicale des Négociants en Diamants, Perles, Pierres Précieuses, et des Lapidaires, warned the members against the deceptive designation given by some dealers to the Japanese pearl in calling it "Perle Fine Japonaise," for these pearls are not genuine, and those dealers who offer them for sale as such lay themselves open to prosecution under the law for the suppression of frauds. For this reason, the Committee decided to put the public on its guard in this matter by publication.[1]

Ruby, Sapphire, Spinel

Burma.—The Burma Ruby Mines, Ltd., according to its report for the year ending Feb. 28, 1920, showed an increasing prosperity compared with the immediately preceding year. The sales of rubies amounted to £91,601, an increase of £40,759 over 1918–1919, when the sales were only

[1] *Recueil Mensuel des Procès-Verbaux des Séances de la Chambre Syndicale des Négociants en Diamants, Perles, Pierres Précieuses, et des Lapidaires*, Paris, No. 47, Jan., 1921

£50,842. The number of loads of ruby earth washed was 754,324, against 903,760 loads in the previous year, but the value of the ruby material was £76,153 compared with £44,168 in 1918–1919. While the cost per load rose from 10.4d. to 1s. 2.2d. the higher value of the ruby gave a profit of 10.03d. per load, against only 1.33d. per load in 1918–1919. It is stated that a good part of this satisfactory result is due to the finding of the great "Peace Ruby," in July, 1919, for the last six months of the year exhibited a considerable falling-off in returns.

In 1920 about 800,000 loads were washed, and rubies valued at £43,000 were produced.[1] This shows a falling-off in yield as compared with 1919. It is stated that on an average a "pin's head" size of ruby is found in a truck-load of earth. However, from time to time large gems appear, notable among which was the so-called "Peace Ruby" found in the Saroktan mine in 1919, and which weighed 42 carats; it was of perfect color, with the crystal faces well developed. A valuation of 300,000 rupees, or £20,000, was put upon it, and it was sold in the rough.

Queensland.—The prosperity which had marked the closing months of 1919 on the Anakie Sapphire Field was continued in the early part of last year. Competition between the various buyers seemed to have the effect of forcing up prices, which, compared with any previous period in the field's history, reached a phenomenally high point. The effect of the high prices was, through the over-booming of the field, to attract thither a far larger population than the industry could support, and then the inevitable reaction set in. It has been the experience on the field for the past 20 years that a period of inflated prosperity is always followed by a term of depression. Doubtless, the great amount of stone that was produced between October, 1919, and April of last year was more than the available markets could absorb, while at the same time this over-supply was augmented by large quantities of cut stone which had been held in Germany being also offered for sale early in 1920. International exchange, also, adversely affected the market for Queensland gems. A feature of the year's mining work on the field was that, with a greatly increased total output, most of the operations were confined to the vicinity of the old workings at Retreat and Policeman Creeks. Towards the end of the period, however, a few miners migrated to Tomahawk Creek, and seemed satisfied with the results obtained, notwithstanding that repeated trials extending over many years have not led to any permanent settlement in this locality. Some fresh ground has also been opened between the New Rush workings, 4 miles from Sapphire, and those at The Scrub, and on this ground a few claims have proved payable.[2]

[1] Communicated by Mr. Montagu Ballye, May 6, 1921.
[2] *Queens. Govt. Min. Jour.*, Apr. 15, 1921.

The following is an estimate, carefully made from all available sources, of the output of the field for the past year, as supplied by Mr. J. Stewart Nisbet, secretary of the Sapphire Progress Association:

Gemstones	£55,050
Mechanical stones—machine and corundum	7,000
Stones cut during the year	1,000
	£63,050
Approximate value of stones sold privately	400
Approximate value of stones held over, unsold	600
	£64,050

Sapphires of a novel type have been found on the Excelsior Claim, 3½ miles south of Ruby Vale, near Placeman's Creek, in Central Queensland, Australia, near the Central Queensland Railroad. They are of blue color, not transparent, but show a well-defined (not movable) star cross, due to crystallization. They occur in alluvial soil, in a second layer of an old river channel. The discovery dates from October, 1920. There is also reported, from some 25 miles above this region, the occurrence of a green, rolled, corundum crystal weighing over 2 oz.; this also is not transparent.

To facilitate the marketing of Queensland sapphires, the Government has entered into an agreement with a firm of gem dealers having offices in Bombay, Paris and London. By the terms of this agreement, the firm is appointed sole agent for the sale of all sapphires which are the property of the Government, for a term of three years, the privilege of terminating the contract at three months' notice being reserved by both parties. The Government is to take all reasonable steps to acquire the entire production of sapphires in Queensland, except of the so-called "fancy stones," defined as orange, golden-yellows, parti-colored, and green. The firm is to appoint a grader, who shall examine, grade and classify the sapphires received from the miners on the field, and shall then consign them to the contracting firm in Paris or elsewhere. The Queensland Secretary for Mines is to receive from the firm monthly advices of the highest ruling price for each kind of sapphire, and also the firm's estimate of the probable price two months later, and the Government will make advances to the miners not exceeding 75 per cent. of the value of the gems as deduced from these advices, the balance, less charges, to be paid to them when the gems have been sold. The money for such advances is to be deposited to the credit of the Government by the gem dealers. Except by consent of the Queensland Government the firm is not to retain possession of the sapphires for more than five months. It is provided that the cost of operating this plan is to constitute a charge against the returns for the stones, and this expense is not to exceed 7½ per cent. on the turnover, when this is not more than £30,000 in a year.

This charge is to be reduced ½ per cent. for every additional £10,000, but is never to be less than 5 per cent. During the first week of this agreement about £4,500 was paid to the miners in the Anakie fields for their sapphires, the gems purchased including about 226 oz. of first-grade blue sapphires, for which £1700 was paid. For 480 oz. of small first-grade blues the miners received £1,980, and £450 was given on second-grade and machine or industrial stones. All these sums represent 75 per cent. of the value of the stones acquired.[1]

United States.—The New Mine Sapphire Syndicate of Utica, Fergus Co., Montana, reports an output for 1920 of 309,195 carats of sapphires, valued at $200,325. Owing to shortage of labor, mining operations were considerably restricted, more especially during the harvest season, and the fact that the electric separator got out of order rendered it necessary to ship the smaller-sized stones to London in the gravel for the first sorting.[2]

Turquoise

A report comes from Argentina that a British mineral prospector, Mr. Robert Davidson, has discovered in the Cordilleras, near a mine in the province of San Juan, a rich vein of turquoise. Samples of the precious materials that have been sent to Buenos Aires were pronounced by an expert to be fine turquoise, and worth about 7 pesos per gram. The vein from which the fragments were taken traverses a basaltic formation, and this is declared to be the first time that turquoise has been found in Argentina.[3]

[1] *Queens. Govt. Min. Jour.*, Feb. 15, 1921.
[2] Communicated by C. T. Gadodem, Jan. 14, 1921.
[3] *South American*, New York, December, 1920.

QUICKSILVER

By W. D. Burcham

The production of quicksilver during 1920 was the lowest on record, records having been kept since 1850. This was due to the inability of American producers to keep their heads above water in the face of the low prices caused by the assimilation of wartime stocks of mercury, and importation of metal produced by the cheap labor of Europe.

Preliminary figures showing the production in the United States in 1920, compiled by F. L. Ransome, of the United States Geological Survey, give a total of 13,070 flasks. Of this output 9366 flasks is credited to California, 3601 flasks to Texas, 79 flasks to Nevada, and 24 flasks to Oregon. So far as is known neither Idaho nor Arizona produced any quicksilver.

In California 10 mines were reported as productive; in Texas 2; and in Nevada and Oregon 1 each. In California the New Idria, Cloverdale, New Guadalupe, Oceanic, Carson, and Oat Hill mines were closed during the later part of the year, most of them with the expectation that work will be resumed when the conditions for mining and marketing quicksilver have improved. The largest producer, the New Idria, lost its reduction plant and a considerable quantity of quicksilver by fire on June 20. Operations were resumed at about half capacity in September, but ceased entirely in November.

STATISTICS OF QUICKSILVER IN THE UNITED STATES

Year.	Production. (b)					Exports.			Imports.	
	Calif. (a)	Texas.	Others.	Total.	Value. (f)	Flasks.	Metric Tons.	Value.	Pounds.	Value.
	Flasks.	Flasks.	Flasks.	Metric Tons.						
1906	19,516	4,516	1,276	861	$1,035,138	6,455	220	$244,299	84	$50
1907	(d)17,532	3,000	400	712	868,678	5,132	175	192,094	16,566	6,719
1908	(d)16,969	2,832	346	685	903,391	2,995	110	124,960	15,113	8,215
1909	16,217	4,188	810	704	941,233	6,803	231	266,243	15,968	8,203
1910	(d)18,536	3,382	500	763	1,054,991	1,923	65	91,077	667	381
1911	(b)18,860	(g)2,396	.....	732	989,254	291	10	13,995	471,944	251,386
1912	20,600	2,700	1,847	855	1,067,742	310	14	13,360	82,706	39,919
1913	15,396	(h)	4,285	670	774,054	1,140	39	43,574	171,653	75,361
1914	11,485	(h)	5,083	536	811,832	1,446	49	70,753	685,605	300,000
1915	14,000	(h)	7,033	716	1,768,225	3,370	115	225,509	421,884	282,852
1916	(b)21,045	(g)8,504	383	1,018	3,768,139	8,880	302	670,475	424,396	515,919
1917	(b)23,938	(g)11,788	433	1,237	3,808,266	10,778	366	998,470	390,525	448,032
1918	(b)22,664	(g)9,495	724	1,119	4,060,064	3,098	105	338,620	503,925	533,622
1919	(b)15,205	5,019	1,191	738	1,933,560	9,107	309	817,328	797,625	791,226
1920	(b) 9,366	3,601	103	455	1,041,156	1,553	53	129,993	1,072,650	971,510

(a) Reported by the California State Mining Bureau, except as noted. (b) Figures of the U.S. Geological Survey. (d) Figures collected by Mineral Industry. (f) Computed at average price at New York. (g) With Nevada. (h) Included in other states.

The year has been a discouraging one to quicksilver mine operators, who have had to face a decline in prices consequent upon a decreased demand for their product and have found little relief from the prevailing high cost of labor and supplies. Such demand as there was for the metal has been met from surplus stocks accumulated during the war, from quicksilver originally sold abroad but resold in this country, and from imports.

No further field work in quicksilver will be undertaken by the U. S. Geological Survey.

Quicksilver Market in 1920

The market at the first of the year was $90 in San Francisco, and after considerable fluctuating reached $102, the high mark of the year, in April. From that time on there was a steady decline which reached a December average of $49.

Although San Francisco is commonly referred to as the "primary market" for quicksilver in the United States, from the fact that the greater part of this metal produced in the country comes from the Pacific Coast and goes through the hands of San Francisco firms, yet it should be noted that that city is not a market in the same sense as New York. Most of the quicksilver that passes nominally through San Francisco is handled on commission and is sold in New York, which

MONTHLY AVERAGE PRICES OF QUICKSILVER
(Per flask of 75 pounds)

Month.	San Francisco.					New York.		
	1916.	1917.	1918.	1919.	1920.	1918.	1919.	1920.
January	$200.50	$80.20	$115.58	$103.07	$89.00	$126.77	$105.50	$90.19
February	200.63	116.25	116.96	91.45	81.00	119.89	89.84	84.43
March	223.75	112.50	115.83	73.68	87.00	121.63	71.56	92.61
April	147.50	115.00	115.46	71.20	100.00	121.87	72.94	102.19
May	97.50	105.00	113.30	78.60	87.00	118.97	83.12	89.56
June	73.81	86.20	113.48	89.83	85.00	122.66	93.25	90.15
July	79.90	102.18	116.69	98.85	88.00	126.63	104.68	90.33
August	75.00	111.10	118.33	103.73	85.00	125.56	107.08	83.81
September	75.06	110.90	119.00	99.83	75.00	127.81	102.52	75.00
October	75.80	100.62	119.33	86.23	71.00	127.18	86.35	67.20
November	75.50	100.75	118.91	82.28	56.00	124.91	90.74	58.42
December	78.00	111.65	115.60	91.13	52.50	117.70	98.27	49.58
Year	125.25	104.36	116.54	89.16	79.66	123.46	92.15	81.12

AVERAGE PRICE OF QUICKSILVER IN SAN FRANCISCO
(Per flask of 75 pounds)

Year.	Price.	Year.	Price.	Year.	Price.
1909	$45.45	1913	$40.23	1917	$104.36
1910	46.51	1914	49.05	1918	116.54
1911	46.01	1915	85.80	1919	89.16
1912	42.05	1916	125.25	1920	79.66

consequently is the great distributing point of quicksilver to the actual consumers.[1]

Production Cost and Tariff

There has been no notable change in the metallurgy of quicksilver, and consequently no lowering of the cost of production. The fact that a market price around $50 per flask resulted in the closing down of all but two of the active mines is an index to the cost of production, although it is probable that all of the mines kept going at a loss for some time before acknowledging defeat, in hopes that conditions would change for the better.

It is generally accepted that a steady price of $75 per flask is necessary to keep the industry alive and hopes are entertained of obtaining a tariff of 50 cts. per lb., which will place domestic producers on a fair competitive basis with the high-grade ores and cheap labor of Europe.

Considerable opposition to this tax by the consumers of quicksilver has been developed, but in view of the fact that domestic consumption would have to increase to several times its present volume to make this tax amount to one cent per capita per annum, and considering the necessity of domestic production in case of war, it is probable that the tariff bill will be promptly passed when brought to the attention of Congress.

Quicksilver in the United States

California.—This State maintained its prestige as the largest producer of the country, having to its credit about three-quarters of the total production. There were ten mines in the State reported as productive in the first quarter, but by the end of the year only the New Almaden was in operation. There is reasonable expectation that this condition is but temporary and that work will be resumed when conditions for mining and marketing quicksilver have been improved.

The quicksilver production of California for 1920 was 9366 flasks (75 lb. each). This is the lowest yield in the history of the State since 1850. The previous bottom level was in 1914, when the output declined to 11,373 flasks. The low-point price in 1914 was $37 per flask. Since the war, prices have again declined, so that during the last two months of 1920 the quotations ranged around $50 to $65 per flask. However, even at those figures, which were below cost of production, the sales of domestic metal were so limited for several months that on Nov. 1 all of the principal operators in California closed down their plants. This included the New Idria, Cloverdale, and Oceanic mines. On June 20, the

[1] U. S. Geol. Surv.

New Idria plant was wrecked by fire; but the company proceeded to rehabilitate it, and had two of the five rotary furnaces again in operation, when compelled to close on account of market conditions. There is plenty of ground, even in California, in addition to what may be in Nevada and Texas, that will warrant development if only a fair price can be assured that will justify exploitation. The domestic quicksilver industry is in danger of complete extinction, if not soon given adequate protection against foreign importations. Manufactured mercurials should also be included in the dutiable tariff list, as a protection to American detonator and drug manufacturers, which would in turn further assist the domestic mines.[1]

Idaho.[2]—Although Idaho has never been a considerable producer of quicksilver it has from time to time yielded a few flasks—enough to arouse interest in the character of the deposits and their possible economic future. The district in which the most activity has been shown is the Yellow Pine, in Valley County, about 50 miles northeast of Cascade. This district has recently been examined, under a co-operative arrangement, by E. S. Larsen, of the United States Geological Survey, and D. C. Livingston, of the Idaho State Bureau of Mines and Geology. Their report, published as Bulletin 715-E of the United States Geological Survey, describes briefly the geology of the district and the principal known deposits of quicksilver ore. Mining development, although some of the deposits have been known for nearly 20 years, is still in an early stage. The ore, mainly cinnabar, occurs chiefly in limestone near the contact of that rock with quartzite. No large masses of ore have yet been blocked out, but the prospects for future production are regarded as fairly good. The most serious handicap to development has been the remoteness of the district from the main lines of transportation. The wagon-road from Cascade is 70 miles long and has steep grades and a generally rough surface.

Texas.—The production of Texas has been second to California since 1899. The mines of the State were governed by the same conditions as were those of California, and but two of them made any production during the year. One of these, the Big Bend, closed down on the first of November.

Other States.—Nevada produced 79 flasks and Oregon 24 flasks in 1920, as compared with 821 and 453 respectively in 1919. The War Eagle Mining Co. of Oregon reports the completion of a 25-ton Scott furnace, which will not be placed in commission, however, under existing conditions.

[1] Fletcher Hamilton, State Mineralogist, California State Mining Bureau, San Francisco, Calif. *Eng. Min. Jour.*, Jan. 21, 1921.
[2] U. S. Geol. Surv. *Press Bull.*

Quicksilver in Foreign Countries

Spain.—The mercury of Spain is produced in the provinces of Ciudad Real, Granada and Oviedo, by far the greatest part of the output coming from the Almaden mines in Ciudad Real, which are owned and operated by the State. Their entire production is contracted to the house of Rothschild of London, with the exception of 1000 flasks per year which are withheld for domestic use.

In 1919 the Spanish production of quicksilver ore amounted to 24,966 metric tons, valued at 6,356,435 pesetas; the output of metallic quicksilver was 1226 metric tons, valued at 19,479,822 pesetas.

The production and exports of mercury from Spain for the years 1908 to 1919, inclusive, were:

Year.	Production, Pounds.	Exports, Pounds.
1908	2,354,513	2,353,629
1909	3,071,008	3,069,959
1910	2,455,924	2,466,935
1911	3,293,672	3,293,392
1912	2,768,932	2,769,085
1913	2,746,932	2,746,386
1914	2,140,984	2,099,978
1915	2,694,021	2,694,394
1916	1,757,657	1,752,538
1917	1,823,204	.....
1918	1,250,008	2,900,804
1919	2,702,840	.....

In 1918 the Almaden mine made the smallest production in its record for the twentieth century. Various reasons for this decrease are given in the official report. In accordance with a law passed on Dec. 23, 1916, the management of the mine was placed in the hands of a council of seven, which, however, did not take control until the beginning of November, 1918. The mine at that time was in a bad condition. It was heavily in debt, development had been neglected, stopes had gone unfilled, supplies had not been replenished, and the equipment generally was old and out of repair. Operating expenses had increased greatly, and as the mine is run on a credit, granted at the beginning of each year by the official approval of a budget, the rapid increase in the cost of labor and materials was an additional factor making for disorganization. Production in 1918 was practically confined to the first 10 months. November and December were occupied in unwatering the twelfth level, repairing equipment, and in general preparation for work in 1919.

Mr. Courtenay DeKalb, who, as United States trade commissioner visited the mine in July, 1919, has stated[1] that the orebodies appeared to be less regular on the twelfth level than on the levels above, and he received the impression that decrease in production was due to a probably temporary lack of available ore. Sections of the workings, however,

[1] Oral communication to F. L. Ransome.

did not indicate that there is any lack of ore or that exhaustion of this famous old mine is anywhere in sight.[1]

Italy.[2]—Mercury is found in paying quantities in Idria and in the Monte Amiata district of Tuscany. The Idrian output in 1914 amounted to 600 tons. Figures for production during the war are not obtainable from Austrian sources. The workers now employed number 1200. As mercury is no longer in demand for war purposes, stocks at Idria are accumulating. Production costs are said to be approximately the same as costs in the Tuscan mines.

Monte Amiata, situated in the Grosseto-Siena region, is the center of the Italian quicksilver industry. The ore-producing zone stretches for 40 kilometers in a direction parallel to the Apennines, and covers an area of 400 square kilometers. The entire region is mineralized, but only special pockets are sufficiently rich in ore to repay the cost of working. There are at present eight active mines. Three mines have lately been worked out and abandoned, but have been replaced by bringing in two new ones.

The most important of the mineral deposits about the Monte Amiata region is red sulphide or cinnabar. Sometimes, but very rarely, the liquid metal is found in the form of minute drops. The wealth of the deposits does not increase with the depth of the mine, but exhausts itself at no great level. The work of extraction ceases at a depth of about 200 meters. The relative superficiality of cinnabar deposits is characteristic of mercury mining the world over. It is an advantage so far as prospecting and operation are concerned, but a drawback in shortening the life of the mine.

The future of the Monte Amiata region lies in the extension, rather than in the depth, of the producing zone. Experts estimate that the region will continue to supply ore in undiminished quantity for several centuries to come. This, however, is dependent upon the discovery and exploitation of new beds. Under present conditions of abnormally high fuel and labor costs, only the richest deposits are being worked at a profit. Cheaper processes of production may be devised that will render available vast deposits of low-grade ore that are not workable at present.

The high cost of fuel is the heaviest item of expense in ore reduction. The ore is always treated on the spot, being first dried in the sun on platforms or in artificial desiccators. The old type of distilling retort ovens have been given up; they were dangerous because of their mercurial fumes, and uneconomical because of waste. Two types of ovens are now in use—one for the treatment of large fragments of ore, which are mixed

[1] *Min. Res. of the U.S.*, 1919, *Part II* (1921.) *Min. Jour.*, Aug. 7, 1920.

with charcoal in simple tank ovens, and special drop or rotating ovens for treating the smaller fragments of ore. Both these types minimize dispersion, but require great quantities of fuel, both wood and charcoal. In addition, enormous quantities of timber are used as mine props for sustaining the galleries. The double call on timber for charcoal and mine props has made adevastating inroad on the scanty forest resources of the surrounding country. It is now proposed to get around this excessive use of wood by the installation of electric ovens for ore reduction. Water-power from the Apennines is available for hydro-electric energy, but electric smelting has not come up to the high expectations of its proponents.

Two minor difficulties add materially to production costs in the Monte Amiata region: (1) The emanations of sulphuretted hydrogen, necessitating the extensive use of electric ventilators; (2) the character of the soil—occasional strata of loose soil are encountered, which become saturated with water and cause the galleries to cave in. The number of workmen employed in the Monte Amiata mines is about 900. Their average wage before the war was 3.50 lire per day; during the war it rose 9 to 10 lire. A strike for higher pay, which lasted for three months, was settled on the basis of new wage agreements based on piece work. Work was resumed in October, 1919, and there are no ascertainable figures as to present average daily wage or production.

As to fuel, native wood and wood charcoal are used, imported coal not being obtainable. The furnaces treat from 14 to 15 tons of ore per day, at a consumption of 220 lb. of wood per ton of mineral. The above consumption estimate does not include the fuel used for drying the ore, which varies according to the dampness of the latter.

The production of mercury (in metric tons) in the Monte Amiata (Grosseto-Siena) districts was as follows in the years 1915–1918: 1915, 985; 1916, 1093; 1917, 1071; 1918, 1038.[1] Total production of Tuscan and Idrian mercury (metal) in 1918 was: Monte Amiata (Grosseto-Siena) districts, 1038 tons; Idria (estimate of the Italian Bureau of Mines), 600 tons; total, 1638 tons.

During the war the Italian Government took over the entire output of mercury at 12 lire per kilo, and fixed the selling price at 25 lire per kilo. Mercury is the one mineral, with the exception of sulphur, that Italy produces in considerable exportable amounts. The proposal has been put forward by Ingegnere Savoia, director of the Monte Amiata mines, with the backing of three great Italian banks, for the formation of a mercury combination for the control of the world's supply. The

[1] Later figures for Italian production, from the official reports, are as follows: 1919, Monte Amiata district, 548 metric tons; Venezia Giulia, 297 tons; total, 845 tons. 1920, Monte Amiata district, 800 tons; Venezia Giulia, 525 tons; total, 1325 tons.

"trust" would be composed of the Monte Amiata and Idria mines, and also the principal mines in Spain. The quicksilver industry in Italy before the war was financed by German bankers. During the period of Italy's neutrality, control passed to Swiss financiers. Within the last two years Swiss money has been replaced by Italian, under the leadership of the Banca d'Italia. The Monte Amiata company is now purely Italian. Prospecting by Italians for new quicksilver deposits is busily going on in Dalmatia and in the Trentino.

RADIUM[1]

By R. B. Moore

The demand for radium in 1920 was stronger than at any previous period in the history of this rare element. Towards the close of 1919 the stocks accumulated during the war had been partially worked off, and a very decided increase in the demand by physicians and hospitals became apparent. This was undoubtedly due to the fact that the medical profession was beginning to realize fully the favorable results which were being obtained by the use of radium in cancer treament. The increased demand was especially apparent about January, 1920, and from that time on until November the radium plants in this country were all working at full capacity. Several small lots of radium from foreign sources were offered for sale in this country, but the amount was small, and the writer has no record of any actual sales of this material. Practically all, if not all, of the radium sold in this country was, therefore, material of domestic production. The general depression which made itself manifest in November affected the radium market materially, and also influenced the production. The slump in the automobile industry made it almost impossible to sell vanadium towards the close of the year, and as vanadium is an important by-product in the production of radium, it meant that the vanadium produced by the radium manufacturers could not be sold or could be sold with difficulty.

Production in 1920

The Standard Chemical Co. of Pittsburgh was as usual the largest producer, but the Radium Luminous Materials Corporation, with its subsidiary, the Radio Chemical Co., and the Radium Co. of Colorado increased their production over previous years. The Ore Products Corporation of Denver, which was the successor to the Chemical Products Co., shut down its plant, and has not resumed operations. The Carnotite Reduction Co., of Chicago, also ceased operations in the fall, and sold its ore deposits in the Gateway District to the Tungsten Products Co., of Boulder, Colo. Quite recently the Tungsten Products Co. has combined with the Radium Co. of Colorado, Mr. Bleeker of the former becoming Vice President of the new company, and Mr. Bulkeley Wells, President of the Colorado Radium Co., retaining the presidency of the

[1] Published by permission of the Director of the Bureau of Mines.

combined organization. The W. L. Cummings Chemical Co. of Lansdowne, Pa., continued operations during the year, but the Minerals Recovery Co., of Denver, after having serious legal troubles went out of existence, and the plant of the National Radium Institute is now owned and controlled by Mr. W. A. J. Bell, of Denver. This plant, however, is not operating at the present time, owing to difficulty in getting ore.

The total production of radium during the year was 32½ grams of radium element, which is much the largest production in any year up to the present time.

The total production of radium in this country since the beginning of the industry in 1913 is probably close to 115 grams of radium element. The amount may be a little greater or a little less than this figure. It is difficult to estimate the total world's production, as figures of foreign production during the world's war are not available. It is probable, however, that not more than 40 grams of radium element have been produced abroad since the discovery of radium by Madame Curie and her husband. A part of this foreign production came from American carnotite ore, as considerable quantities of this ore were shipped to Europe before actual production started in this country. It is probable that at least 10 grams of the 40 mentioned came from American ore. Therefore, the production in 1920 in this country was almost as large as the total production outside of this country since the discovery of radium, and certainly as much as the total amount of radium produced from foreign ores.

Technology

No radical changes in technology were inaugurated during 1920. The methods used come under the general heads (1) acid leaching, (2) alkali leaching, (3) alkali fusion. Sometimes these methods are more or less combined. It has not been possible up to date to get any method which will give maximum efficiency on any type of carnotite ore. An ore low in sulphate can perhaps best be treated by leaching with hot, reasonably concentrated nitric acid. An ore high in sulphate does not give as good a recovery by this method, perhaps, as by fusion with an alkali or by boiling with a solution of sodium carbonate followed by a leach with dilute C.P. hydrochloric acid. Certain ores high in carbonaceous material are also difficult to treat. Carnotite concentrates, which are always below 100 mesh and frequently below 150 mesh, are difficult to treat by any leaching method owing to difficulties of filtration. Consequently, any plant has to adapt its ore more or less to its process or have a combination of two processes which may be used as the occasion requires. Some improvements have been made in purification by the

usual method of crystallization, and we know a little bit more about the crystallization "factors" and the concentration of acid which is advisable. An article by J. L. Nierman[1] takes these points up in connection with mesothorium, the data, however, applying very materially to radium crystallization also.

An important contribution during 1920 was the new determination of the absolute value of the radium-uranium ratio by Dr. S. C. Lind and L. D. Roberts.[2] A knowledge of the correct value of this ratio is important to radium technology owing to the fact that the whole question of the determination of recoveries of radium depends on this factor. Previous figures obtained by other workers are as follows: 3.8×10^{-7} (Rutherford and Boltwood); 3.4×10^{-7} (Boltwood;) 3.23×10^{-7} (corrected value by Rutherford); 3.328×10^{-7} (Heimann and Marckwald); 3.383×10^{-7} (Becker and Jannasch). Between the corrected value of Rutherford (3.23×10^{-7}) and that of Becker and Jannasch there is a discrepancy of about 5.5 per cent. and between that of Heimann and Marckwald and of Becker and Jannasch a discrepancy of 2 per cent. A redetermination of this figure under extremely careful conditions was, therefore, important, and the value obtained by Lind and Roberts was 3.40×10^{-7}, which agrees with the average of the two determinations of Becker and Jannasch and with the second figure obtained by Boltwood. It, therefore, can be considered that this important constant has been definitely settled.

Some other radioactive constants which are important have been carefully considered by Stefan Meyer of Vienna. It is not possible in an article of this character to go into details, but the following figures on the half-life periods of some of the radioactive elements have been suggested by him as probably the more reliable among the numerous determinations that are available: U_1, 4.5×10^9 years; UX_1, 23.8 days; UX_2, 1.15 min.; ionium, 9×10^4 years; radium, 1580 years; RaF, 136.5 days. UY he considers as branching off to the extent of 4 per cent. from U_2, and gives it a half-life period of 24.6 hours. In the actinium family he puts prot-actinium as the parent, with a life of about 10^4 years. To actinium he assigns 20 years; AcX, 11.2 days; AcC, 2.1 min.; and AcD (which he calls AcC″), 4.76 min. In the thorium family he adopts 2.2×10^{10} years for thorium, and 60.8 min. for ThC. He calls the 65-per cent. branch ThC′, and the 35-per cent. branch ThC″, to which he assigns 3.20 min.

Uses

As already stated, the demand for radium for therapeutic use has greatly increased during 1920. The demand not only came from a large

[1] *Jour. of Phys. Chem.*, March, 1920.
[2] *Jour. Am. Chem. Soc.*, **42**, No. 6, June, 1920.

number of individual physicians, but also from a number of hospitals. Probably the largest individual sale made during the year was to the New York State Hospital for Cancer, at Buffalo. Through an appropriation made by the New York legislature, more than 2 grams of radium calculated as element was purchased during the year for this hospital. In connection with larger amounts of radium, it has become almost the universal practice to use the radium emanation instead of the radium salts themselves. This is on account of two definite advantages. First, it eliminates the danger of loss of the radium itself since the radium under such conditions can be kept properly protected in a fireproof vault, and also the emanation can be used in a more concentrated form, and, therefore, can be used more efficiently locally. The old-type "applicator" is very largely disappearing, although it is still used to some small extent.

Encouraging results have been obtained in connection with cancer-treatment by radium. Some types of cancer which apparently gave no response to radium treatment a few years ago can now be benefitted or even cured. Many of the surgeons who a few years ago were skeptical concerning the use of radium now recognize its value. On the other hand, it is necessary to remember that radium is not a cure-all, and is really a handsmaid to surgery and not a substitute.

Radium luminous paint is still being used in considerable quantities for watch and clock faces, for electric push-buttons, etc. Since a satisfactory demand for radium has arisen from the doctors and hospitals of the country, the manufacturers of radium salts are not quite so prone to push the use of luminous material as was the case two or three years ago. A use for radium which has developed rather slowly but promises to be of some importance is in connection with the coloring of precious stones by means of the rays from radium. Colorless sapphires are turned yellow or orange, and, in addition, other gems including the diamond may under certain conditions have a color imparted to them, or if already colored, may have this color modified or changed.

Prices

There is probably no product which maintained its pre-war price more steadily during the war period and afterwards than did radium. Before the war the price fluctuated over a period of several years between $100,000 and $125,000 per gram of radium element. During 1920 the price varied somewhat depending upon the particular producer involved, and also on the quantity of radium to be sold. In the early spring one sale of over two grams of radium element was made at $89,000 per gram. Several bids received on this same material were around $100,000 per gram. The average price on smaller lots, however, has been from $110

to $120 per milligram. Test quotations obtained during December were as follows: one firm $110 per milligram of radium element, two firms $120 per milligram of radium element.

Mesothorium

Of all of the thirty-odd elements which are radioactive, mesothorium is perhaps the most interesting and important next to radium. Indeed it has become a very satisfactory substitute for radium under certain conditions. It decays, however, at a much more rapid rate than radium, its rate being about 250 times as great as the rate at which radium changes into its disintegration products. However, mesothorium and its products give off all of the rays that were obtained from radium, and whereas the velocity and penetrating power of these rays vary to some extent from those which are obtained from radium, outside of the fact that the element changes at a much more rapid rate, it is a very satisfactory substitute for radium in luminous paint, and even to a certain extent in cancer treatment. Owing to the fact that mesothorium itself does not give out alpha rays, it is necessary in order to obtain the alpha radiation required for luminous paint to allow the mesothorium to age for at least one year before use, since the alpha radiation greatly increases and comes to a maximum during the fifth year after separation. The maximum gamma-ray activity is attained during the fourth year after separation.

Mesothorium is obtained as a by-product in the manufacture of thorium nitrate for incandescent mantles. The mineral used, monazite, is obtained mainly from Brazil and from India. The Brazilian concentrate which is shipped into this country carries about 96 per cent. monazite mineral, the whole containing about 6 per cent. thorium oxide. The product from India contains more thorium oxide than the South American concentrate. Up to two or three years ago, the mesothorium was not recovered, but both of the large companies which make thorium nitrate in this country, namely, the Welsbach Co. and the Lindsay Light Co. have now recovered their mesothorium for several years. Under normal conditions, from three to four gram-equivalents[1] of mesothorium are produced each year. The price has averaged from $60 to $70 per milligram, and the material has been exclusively used for luminous paint.

Since mesothorium is isotopic with radium,[2] the chemistry of mesothorium is practically identical with the chemistry of radium. The methods used for the recovery of mesothorium are, therefore, very similar to those used for the recovery of radium. In addition, since all

[1] Gram-equivalent means a quantity of mesothorium material which has the same activity at the end of 40 days as one gram of radium element in equilibrium with its disintegration products. The activity of the mesothorium is measured through 10 mm. of lead.

[2] Two elements are isotopic when their chemical properties are identical and they cannot be separated chemically.

monazite contains small quantities of uranium minerals, the finally refined mesothorium always contains some radium, usually from 12 to 25 per cent. of the activity being due to radium. The usual method is to heat the ore with sulphuric acid, the thorium and other rare earths going into solution, but the mesothorium and radium being left behind in the tailings as insoluble sulphates. In order that there may be enough insoluble sulphate to handle mechanically, two or three pounds of barium chloride per ton of ore is added to the ore or to the acid during heating so as to give sufficient barium sulphate to be later recovered without too great a loss. Any mechanical method for separating the barium sulphate with its associated mesothorium and radium sulphates in order to get a reasonably high concentrate can be used, and then the ordinary methods of purification of radium can be applied. The concentrate may be heated with charcoal so that the sulphates are reduced to sulphides provided there is not too much silica present, or the concentrate may be boiled with strong sodium-carbonate solution and the mesothorium-radium-bearing carbonates be converted to chlorides by treating with dilute hydrochloric acid. From this point fractional crystallization is used as in the case of radium.

SELENIUM AND TELLURIUM

The production of selenium in 1920 was 92,141 lb., valued at approximately $175,508. As compared with 60,025 lb. valued at $125,966 produced in 1919, this was an increase of 53 per cent. in quantity and 39 per cent. in value. Selenium was recovered in 1919 as a by-product in the electrolytic copper refineries operated by the Raritan Copper Works, Nichols Copper Co., and American Smelting & Refining Co.[1]

Sales of selenium reported during 1919 amounted to 18,206 lb. Quoted prices ranged from $1.50 to $2 per lb. for the amorphous powder. During 1920 the prices quoted were from $1.80 to $2.10, depending on quantity.

Although efforts to discover new uses for tellurium have been made by the Government in co-operation with metal refineries which have accumulated large stocks, no important commercial applications have yet been developed. It has been used in a small way in high-resistance alloys, for coloring porcelain and glass, staining silver, in medicine, and in the manufacture of certain special dyes. However, all of the above uses represent only a very few hundred pounds per year.[2]

Practically all the selenium which is now being used commercially is consumed by the glass industry, which uses it as a coloring and deoxidizing agent. Several compounds of selenium are made in small quantities, but they have had little use. A new compound is selenium oxychloride, which has been experimented with by Prof. Victor Lenher of the University of Wisconsin, and which appears to have great possibilities as a solvent for many organic materials. Following is an abstract of information which he has published[3] concerning this compound:

Selenium oxychloride is a slightly yellow liquid, transparent to visual light, but so opaque to ultraviolet that it makes practically a screen for all wave lengths below 4050. It is miscible in all proportions with carbon tetrachloride, chloroform, carbon disulphide and benzene. With saturated aliphatic hydrocarbons at ordinary temperatures there is apparently no chemical reaction, or if there is any it is very slight. The unsaturated hydrocarbons of the same series, on the other hand, unite with selenium oxychloride directly, frequently with the manifestation of great energy. Amylene, for instance, reacts with it with great violence, and with such hydrocarbons as turpentine the reaction is like that of halogens on turpentine. It is thus possible to separate such

[1] U. S. Geol. Surv.
[2] *Eng. Min. Jour.*, Jan. 22, 1921.
[3] *Jour. Am. Chem. Soc.*, Jan., 1921; *Chem. Met. Eng.*

unsaturated aliphatic hydrocarbons as amylene from the saturated heptane by simple contact with this solvent. Again, if a mixture of heptane and benzene is treated with it, the benzene goes into solution, while the lighter heptane rises to the top and forms an immiscible layer.

Sulphur, tellurium and selenium dissolve with ease in the cold liquid: most metals react with it, forming the chloride of the metal and red-brown selenium chloride. It dissolves many metallic oxides, and solutions of molybdenum trioxide and the pink carbonate of cobalt show remarkable photochemical reactions. With carbonates its reactions are of considerable variety. Barium sulphate is peptized by it to a gel much resembling freshly precipitated aluminium hydroxide, but the colloidal form of barium sulphate is immediately changed back to the ordinary form when treated with water.

Protein materials, such as hair, bristles, silk and leather, are readily dissolved in the cold. Vegetable and fish oils behave in a way similar to treatment with sulphur monochloride. With linseed oil it forms a rubber-like mass similar to that produced by sulphur monochloride. Menhaden oil reacts with selenium oxychloride also to form a waterproof rubber-like mass. Rubber reacts chemically with it, and the chemical character is changed in the process. Phenolic condensation products, gums, resins, dried paints, shellac, dried varnish, agar, celluloid, gelatine, glue—including the insoluble casein glue—are all readily dissolved by it it in the cold.

Natural asphalts, resins and bitumens dissolve with ease in the cold when they are of unsaturated character. Such a product as ozokerite, which consists principally of saturated hydrocarbons, behaves very like paraffin with it. Natural coals brought into contact with selenium oxychloride react so far as the bituminous and resinic materials are concerned, leaving a carbonaceous residue behind. Thoroughly ignited coke loses nothing with the reagent, whereas incompletely coked soft coal goes partially into solution. Anthracite coal shows little reaction, semi-anthracite loses considerable, and bituminous coals lose a great deal. Lampblack loses its hydrocarbon content, leaving behind carbon.

The carbonaceous material separated from iron and steel by the copper-chloride treatment consists of graphite and what is believed to be unsaturated hydrocarbons. With selenium oxychloride a black extract is produced which shows that at least a part of the material has been acted on.

SODIUM SALTS

By Chester H. Jones

Post-war industrial inflation extending up to the last quarter of 1920 in common with its effect on industry in general made a marked impression on the sodium salts. The production, imports and exports of sodium compounds all increased in the United States in 1920 over 1919. The sale of all sodium compounds and of metallic sodium amounted here in 1920 to 9,886,020 tons, valued at $139,536,338, an increase of about 8 per cent. in quantity and 17 per cent. in value. Sodium bichromate, ferrocyanide, nitrite, thiosulphate and sal soda were the only ones to show decreases, while bicarbonate, bisulphite, phosphate and borax made new high records.

Salts from natural sources exclusive of common salt and including sodium bicarbonate, sulphate, trona and borax amounted to 41,683 short tons valued at $1,513,179, as compared with 29,120 tons valued at $874,083 in 1919.

The U. S. Geological Survey has issued the following table showing the sodium compounds sold in the United States in 1919 and 1920:

SODIUM COMPOUNDS SOLD IN THE UNITED STATES
(In short tons)

Product.	1919. Quantity.	1919. Value.	1920 Quantity.	1920 Value.
Sodium acetate	778	$116,667	1,020	$143,887
Sodium benzoate	126	230,224	201	365,841
Sodium bicarbonate	134,962	3,486,635	188,906	4,256,715
Sodium bichromate	26,526	6,233,566	25,973	5,531,954
Sodium bisulphite	11,819	687,750	22,059	1,028,373
Sodium bromide	499	493,319	543	523,724
Sodium carbonate:				
Soda ash	981,054	29,895,343	1,242,490	39,083,726
Monohydrate	30,796	710,748	2,267	115,256
Trona			10,609	343,911
Sal soda	80,090	2,229,994	62,857	2,128,937
Sodium chloride (common salt)				
Salt in brine	2,850,639	1,423,424	2,819,881	1,834,362
Rock salt	1,642,057	6,240,450	1,683,020	7,338,079
Evaporated salt	2,390,206	19,410,820	2,444,002	21,334,840
Sodium citrate, tartrate, and bi-tartrate	33	58,128	45	67,115
Sodium ferrocyanide	3,437	1,346,285	2,930	1,318,049
Sodium fluoride and acid fluoride	(a)	(a)	934	210,782
Sodium fluosilicate	(a)	(a)	719	143,800
Sodium hydroxide	311,388	20,091,978	382,680	25,894,641
Sodium iodide	12	86,985	10	29,905
Sodium nitrite	676	151,621	140	56,184
Sodium phosphate	14,760	1,733,996	30,515	3,233,896
Sodium silicate	300,138	5,879,628	304,503	5,751,088
Sodium cyanide, peroxide and nitrate (refined)	17,188	5,331,123	8,633	3,415,085
Sodium sulphate:				
Salt cake	134,685	2,035,543	184,946	2,076,350
Glauber's salt	42,087	860,977	44,479	963,293
Niter cake	83,402	271,424	308,638	788,544
Sodium sulphide	45,448	2,645,181	42,952	2,962,033
Sodium sulphite	(b)	(b)	3,778	197,782
Sodium tetraborate	28,518	4,351,891	35,281	5,674,012
Sodium thiosulphate	32,212	1,709,223	24,868	1,283,697
Other sodium compounds	2,190	1,144,883	6,141	1,240,477
	9,165,726	$118,857,806	9,886,920	$139,336,338

(a) Included in other sodium compounds.
(b) Included in sodium bisulphite.

The prices obtained in 1920 were generally better than in 1919 up till the depression of industrial activity in the last quarter, when most of them fell below the levels at the beginning of the year. Imports of compounds which made significant changes over 1919 and including salt, cyanide, nitrate and nitrite among other minor salts were 1,631,065 short tons valued at $66,855,955, an increase over 1919 of 1,108,708 tons. The only compounds whose imports exceed the domestic production were sodium nitrate and nitrite.

Exports of domestic sodium compounds made good increases in 1920 to a record figure. Japan, Canada and Mexico are the leading consumers. The exports, not including sodium nitrate and salt re-exported, but including soda ash, sal soda, domestic salt, caustic soda, sodium silicate and other sodium salts, were valued at $27,191,429 in 1920 against $18,545,420 in 1919.

At present writing (1921) the markets have become depressed below pre-war levels, large producers are closed down and these industries are thoroughly liquidated.

Salt

United States.—Salt produced and marketed in this country in 1920 was 6,965,188 short tons valued at $30,539,168, an increase of 1.2 per cent. in quantity compared with 1919, and an increase of 12.8 per cent. in value. The quantity was only slightly less than that produced in the peak year, 1918, while the value was the greatest on record. The average price per ton of all salt sold by the producers in any form rose from $3.93 to $4.38. The average price and total value has increased more than 100 per cent. since 1916.

PRODUCTION OF SALT IN THE UNITED STATES (a)
(In barrels of 280 lb.)

Year.	California.	Kansas.	Louisiana.	Michigan. (c)	Nevada.	New York. (c)	Ohio and W. Virginia.	Texas.	Utah.	Other States.	Total. Barrels.
1909	886,564	2,769,849	(d)	9,966,744	16,107	9,880,618	3,835,267	(d)	246,935	2,505,562	30,107,846
1910	937,514	2,811,448	1,372,248	9,452,022	17,535	10,270,272	3,829,475	382,164	249,850	983,128	30,305,856
1911	1,086,163	2,159,859	(d)	10,320,074	12,856	10,082,656	4,485,886	385,200	272,420	2,391,710	31,196,824
1912	1,090,000	2,573,626	(d)	10,946,739	12,536	10,502,214	5,408,300	373,064	283,293	2,135,036	33,324,808
1913	1,082,993	2,698,079	(d)	11,528,800	8,971	10,819,521	5,424,056	355,529	330,443	2,189,913	34,438,305
1914	(d)	2,967,864	(d)	11,670,976	4,436	10,389,314	5,628,265	433,979	375,457	2,332,649	34,804,583
1915	1,048,457	3,765,164	(d)	12,588,788	6,929	11,217,471	6,112,482	444,978	394,850	2,652,377	38,231,496
1916	1,124,236	4,564,793	(d)	14,918,278	(d)	14,087,750	6,706,193	541,157	433,236	2,834,880	45,449,323
1917	1,536,814	5,335,543	(d)	16,078,136	(d)	15,457,636	7,511,764	608,436	565,879	2,750,114	49,844,121
1918	1,463,979	5,853,600	(d)	17,165,179	693	15,218,071	7,971,172	568,978	672,886	2,748,787	51,705,317
1919	1,429,393	5,525,543	(d)	17,802,700	(d)	13,913,064	7,216,636	(d)	552,400	2,723,850	49,163,586

(a) Statistics of the U. S. Geological Survey except for New York since 1908, which are from reports of the State Geologist. (c) Includes brine used in manufacture of alkali. (d) Included in "Other States."

CONSUMPTION OF SALT IN THE UNITED STATES
(In tons of 2000 lb.)

Year.	Production.		Imports.		Exports.		Consumption.	
	Amount.	Value.	Amount.	Value.	Amount.	Value.	Amount.	Value.
1906.....	3,944,133	$6,658,350	170,505	$502,583	33,988	$274,627	4,080,650	$6,886,306
1907.....	4,160,729	7,439,551	153,435	452,227	30,802	232,895	4,283,362	7,658,883
1908.....	4,024,345	7,486,894	156,609	440,484	26,627	202,338	4,154,327	7,725,040
1909.....	4,215,070	8,343,831	158,487	447,983	40,158	269,273	4,333,397	8,522,541
1910.....	4,242,792	7,900,344	142,549	388,015	49,013	320,926	4,336,328	7,967,433
1911.....	4,365,756	8,345,692	137,759	378,083	48,873	335,285	4,454,642	8,397,490
1912.....	4,665,473	9,402,772	136,391	361,664	62,410	418,525	4,739,454	9,345,911
1913.....	4,821,368	10,123,129	150,601	416,375	70,289	515,194	4,901,680	10,024,310
1914.....	4,872,656	10,271,358	130,752	385,752	82,295	586,055	4,921,113	10,071,055
1915.....	5,352,409	11,747,686	123,576	366,475	80,474	613,850	5,395,511	11,500,311
1916.....	6,632,906	13,645,947	121,967	342,588	84,065	567,411	6,670,808	13,998,535
1917.....	6,978,177	19,940,442	65,840	280,135	113,993	1,000,773	6,930,024	19,219,804
1918.....	7,238,744	26,940,361	40,316	284,032	136,783	1,677,577	7,142,277	25,546,816
1919.....	6,882,902	27,074,694	62,821	324,402	121,701	1,396,625	6,829,022	26,002,471
1920.....	6,965,188	30,539,168	137,654	676,499	139,272	1,901,593	6,963,570	29,314,074

In 1919 fifteen States and Territories produced salt, those leading in quantity being Michigan, New York, Ohio, Kansas, California, Louisiana and Virginia. California had 22 plants operating, Kansas 10, Louisiana 2, Michigan 23, New York 16 and Ohio 7, making a total of 102, the same as in 1918. Salt in brine showed an increase in quantity of 20,039 tons or 0.7 per cent., which being sold largely to chemical works or produced by them gives some index of the increased activity in chemical industry. Salt manufactured by evaporating natural and artificial brine made up 35 per cent. of the total production in 1919, with the States producing the largest quantity in the following order: Michigan, New York, Kansas, Ohio and California.

Canada.—The total sales in 1920 from domestic sources, including the salt equivalent of brine used for chemical manufacturing, were 210,211 short tons valued at $1,547,879, as against sales in 1919 of 148,301 tons valued at $1,397,929. These values as far as possible exclude the value of packages. The value of packages was in 1920 $753,763 as compared with $573,795 in 1919. By grades the production in 1920 included table and dairy, 42,475 tons; common fine, 39,963 tons; common coarse, 122,646 tons; land salt, 5127 tons. The production by grades in 1919 was: table and dairy, 34,396 tons; common fine, 47,571 tons; common coarse, including brine, 64,426 tons; land salt, 1908 tons.

The number of men employed in 1920 was 341 and wages paid $470,005. In 1919 the average number of men employed was 329 and wages paid $350,141.

As usual the Canadian production was obtained almost entirely from the salt field in southern Ontario. Some years ago there was a small production from brines at Sussex, N. B., and at Lake Winnipegosis in

Manitoba, and during 1919 there was an experimental production of salt from brines flowing from springs in the Province of Saskatchewan, near Senlac. Development has continued on the deposit of rock salt near Malagash, Cumberland County, N. S., the shipments in 1920 having been 3023 tons valued at $32,000. This deposit has attracted considerable attention through the discovery of potash minerals associated with the salt.

In diamond-drilling near Athabasca, several years ago, two strata of salt were penetrated by two drills, the holes being 155 ft. apart. In the one hole the upper stratum was 80 ft. and the lower 100 ft. thick, while in the other hole the upper stratum was 90 and the lower one 100 ft. thick. The holes were bored for oil through the celebrated McMurray tar-sands, and consequently little notice was taken of the salt at the time. Evidently it is this same deposit of salt that has been demonstrated at Fort McMurray. Salt springs are prevalent at many points in the Mackenzie River basin; the question in the past has been whether they were not too remote from transportation facilities to be of value. The discovery of oil at Fort Norman, if ultimately it proves to exist in commercial quantities, probably will completely alter transportation problems. Next year is likely to see an enormous amount of exploration work in northern Alberta and in the Northwest Territories.

Caustic soda and chloride of lime are manufactured by the Canadian Salt Co. at its chemical salt works at Sandwich, Ont. Brunner, Mond, Canada, Ltd., has completed and placed in operation at Amherstburg, Ont., a chemical plant for the manufacture of soda ash from brine.

The imports of salt cake (sodium sulphate) in 1920 were 42,974 short tons valued at $958,628; soda ash (sodium carbonate), 7458 tons valued at $372,936; caustic soda, 4206 tons valued at $384,260; sal soda, 5064 tons valued at $200,788; and chloride of lime, 17,460 tons valued at $1,034,006. The imports of salt from the United States decreased slightly in 1920, probably due to the development of new salt deposits.

Exports of salt in 1920 were 303 tons valued at $9181. The imports of salt were 155,646 tons valued at $1,434,687 and included 54,338 tons of fine salt in bulk, 28,712 tons of salt in packages, and 72,596 tons of salt imported for the use of fisheries.

The exports of salt in 1919 were 617 tons valued at $14,573 and the total imports were 147,406 tons valued at $1,310,129.

The calculated consumption of salt in 1920 was 365,554 tons valued at $2,973,385, as compared with a consumption in 1919 of 295,090 tons valued at $2,693,485.

India.—The salt department of the Government of the Sind Province reports that for the fiscal year ended Mar. 31, 1920, there was a great

decrease both in production and issues, a decrease which was inevitable when the special circumstances of the war ceased. Shortage of supply and difficulties of transport throughout India led to a keen demand for Sind salt.

There are two chief centers of salt production in the Province—Maurypur and Darwari. During the period under review production at Maurypur fell from 35,260 to 26,954 tons, and the aggregate out-turn of all the salt works in Sind from 59,450 to a little over 29,725 tons.

Although the number of tanneries using duty-free salt increased from two to three, still the salt issued was less than during the previous year.

The assistant commissioner has prepared schemes for the introduction of more economical methods of manufacture and storage of salt at Maurypur and its transport, which have been submitted to the Government for its consideration. There is considerable hope of private enterprise coming forward to develop manufacture at Maurypur, and to establish an oversea trade with Calcutta, by which means alone the natural advantages of Maurypur as a source of salt supply can be utilized.

Maurypur salt is usually described as sea-salt, but is not obtained, as is sea-salt proper, from sea-water direct, but from subsoil brine collected in pits sunk on the foreshore between ordinary and springtide levels. The number of evaporating pans licensed in 1918–19 was 232.

Germany.—In connection with the establishment of a special organization called the Deutsche Salzwerke G.M.B.H. for the German salt export trade the following figures are available: Exports of table and industrial salt to European and overseas countries amounted in 1920 to 1,334,522 short tons valued at 280,000,000 marks, as against 621,446 short tons valued at 72,000,000 marks in 1919 and 440,800 short tons at 5,000,000 marks in 1913.

Spain.—Although the production of salt in Spain for 1919 was normal (about 302,000 short tons) there was a very large stock of salt on hand, owing to the scarcity of shipping facilities and the extremely high freight-rates prevailing during the war. This stock represented a total of not much less than the combined harvests of 1917, 1918 and 1919.

The salt known as Cadiz salt is considered of very high quality, especially for the curing of fish. Cadiz salt is obtained from the solar evaporation of sea-water in the San Fernando district, contiguous to the Bay of Cadiz and the Atlantic Ocean.

Portugal.—Portugal exports from 150,000 to 200,000 tons of salt annually. The principal salt-producing districts are Aveiro, Setubal, and the district along the Tagus. Before the war Portugal exported salt to the Netherlands, France, Newfoundland, Norway, Sweden, and Ireland,

but now the Netherlands, Sweden, and Norway buy salt from Germany, and France buys from England. The Portuguese salt crops harvested in 1917 and 1918 are still unsold.

Holland.—Hitherto Holland has been entirely dependent upon foreign sources for its salt, but in 1919 the Royal Netherlands salt industry struck rock salt with the drill in the Provinces of Gelderland and Overyssel. Toward the end of 1919 the mines were delivering five carloads a day, and it is expected that the production may increase until Holland will become independent in respect to salt.

Poland.—Poland has rich salt deposits in the Provinces of Galicia and Posen and in what was formerly Russian Poland. The mine at Wielicka, in Galicia, is one of the largest and best known in the world. The total production just before the war of the territories now included in Poland was 225,491 tons, of which 63 per cent. came from Galicia.

Siberia.—Salt is found in Siberia in saline springs, in salt lakes, and as rock salt. Salt lakes occur in the Tobolsk and Tomsk governments. Brine springs are found in the Yenisei and Irkutsk governments and in the Yakutsk Province. Although extensive deposits of salt are available in Siberia, very little is produced, and salt is imported into western Siberia from European Russia and Germany to the extent of 9000 tons annually. The salt that is produced in Siberia is generally obtained by the crudest methods and without proper cleaning.

Dutch West Indies.—The manufacture of salt in Curacao and the other islands of this colony, principally those of Bonaire and St. Martin, is quite an important industry and is carried on extensively at a comparatively small cost. The product, known as "sola salt," is manufactured simply by the evaporation process, which takes from 4 to 5 months. At present some 12 different companies are engaged in its production on the island of Curacao.

One of the largest companies, the St. Nicolas estate, which has an area of about 490 acres, is situated almost at the extreme west end of Curacao and comprises 12 salt ponds. It is estimated that the yearly production of the estate is about 40,000 bbl. (1 bbl. = 286 lb.). These ponds, which have an average depth of 3 ft., are filled with sea-water through an artificial canal about 3280 ft. in length leading direct from the ocean, and when full are closed by a dam. The canal is also used for transporting the salt to the shore where a warehouse is located which will store some 7000 bbl. At the ponds in Curacao no process is employed by which the pure salt is separated from the magnesia and potassium salts, although this separation process is followed at the salt ponds of Philipsburg, on the Island of St. Martin.

Sodium Nitrate

Coincident with the world-wide industrial depression in the latter half of 1920 the market and production of Chilean nitrate fell off to a marked degree. In the first half of the year the producers were in good condition. The large companies added to their holdings by buying out the smaller concerns and acquiring nitrate deposits not yet worked. The feeling in the industry was most optimistic, based on the probable demands from central Europe, principally Germany, which has always been a large user of nitrate as fertilizer, and the fact that the production of the artificial, or rather, electrically manufactured nitrate, had not been so successful as anticipated and could not compete with the natural product of the deposits in price.

There have been two reasons why the nitrate-producing companies did not show large profits in 1919, the principal one being the small demand after the armistice was signed, amounting to an almost complete suspension during the early part of the year 1919, and only about 55 per cent. of the "oficinas" (works) were in operation during the second half of the year. The second cause of the small profits for the year 1919 was the fact that contracts had been made at a low price, 9s. per quintal, for their output for deliveries up to the end of March, 1920. (The Spanish quintal, which is in use in the nitrate industry of Chile, is equivalent to 101.4 lb.)

When the price began to go up toward the end of the year the producers did not share in the increase nor in the higher prices prevailing during the first three months of 1920, the prices going as high as 16s. 1d. per quintal in April, and later 16s. 3d. was asked by the brokers. The cost of production in the meantime had risen considerably, owing to strikes of the workmen and the stevedores in the ports of shipment, making the cost delivered alongside much higher than in September, 1919. This, of course, made a reduction in the profits of the companies producing the nitrate of soda.

However, at mid-year 1920, the old contracts at the low price were practically all completed and the new contracts were made at prices over 15s. per quintal, possibly over 16s. per quintal, and the companies were in a better position than at any time since the armistice was signed to do a profitable business.

At the close of 1920 there were considerable stocks of nitrate in the hands of producers and dealers, due to the delay of purchases until the actual consuming season. Prices declined during the year, being quoted in February at $3.85 per cwt. and in December at $3. The decline tended to hold off consumers from the market and made curtailment of

production probable. The deliveries in the United States for the last half of 1920 are estimated from advices abroad at 545,000 tons, compared with 105,000 tons for a similar period in 1919. The total supply in sight on Dec. 31 was estimated at 2,241,000 tons (of which 1,340,000 tons is the stock in Chile), compared with 2,134,000 tons on the same date in 1919. The prospects of a large increase in consumption are doubtful because of the uncertain economic situation.

Chile supplies practically the entire world with nitrates, and has a nitrate Association, consisting of about 97½ per cent. of the producers, which negotiates the sales. Since its inception on Jan. 10, 1919, it has sold 3,285,000 tons. About 620,000 tons was sold outside the organization during the same period. Cost of production, due to a drop in the price of coal and bags and lower exchange, has fallen appreciably. Germany prohibits the importation of Chilean nitrate and relies entirely on domestic production of synthetic nitrates, which is greatly encouraged through financial arrangements. It is estimated that German synthetic nitrogen production will amount to 1,250,000 tons for the year ending June, 1921.

According to figures kept by individuals engaged in the nitrate business, compiled from periodical official announcements, the total exports of nitrate from Chile in 1920 amounted to 60,679,834 Spanish quintals. The number of Spanish quintals shipped per month were as follows: January, 9,039,452; February, 6,081,230; March, 5,417,956; April, 5,057,414; May, 5,237,182; June, 2,411,158; July, 3,104,021; August, 4,274,873; September, 5,479,125; October, 4,626,940; November, 3,581,938; and December, 6,368,545.

The directorate of the Nitrate Association early in 1921 issued a circular to its members warning them that in view of commercial conditions throughout the world it would not be prudent to rely on the association being able to make any further large sales of nitrate, before June 30, 1921, when the present nitrate year terminates. For this reason the association recommends that its members avoid accumulating large stocks in Chilean ports in order to avoid the unfavorable effect which the existence of such stocks must have on the market in general.

The depression in the nitrate market continues with no sign of improvement. The association is not in a position to sell at the market price, which is far below the figure fixed by its own price scale, because to do so would bring into operation the "fall clause" in the sale contracts already made. By this clause persons who have purchased nitrate for delivery between now and June 30, 1921, would be entitled to the benefit of any reduction which the association might make in its scale of prices, because of the fact that about three-fourths of the estimated output for

the current year has already been sold. The operation of this "fall clause" would involve a tremendous loss.

At a special session of the directorate of the Nitrate Association, held on Jan. 26, 1921, the prices of nitrate for May and June were set at 17s., the figure also ruling for April. The directorate also announced that it would guarantee that the prices for the first 10 months of the coming nitrate year—from July 1, 1921 to Mar. 31, 1922—would not be less than 14s. per Spanish quintal.

The maintenance of these high prices during the last two months of the nitrate year virtually made impossible any sales by the association for delivery within that period. The association apparently intended to make no serious effort to effect further sales for 1921. A large part of this year's exports is still unconsumed and will be left on the hands of the dealers in Europe and the United States. The maintenance of the April price through May and June, and the announcement that the price for the 10 months after July 1 would not be less than 14s. was intended to protect the interests of these dealers, who purchased their stocks at the high prices fixed by the association for this year, and also to give the banks financing the purchases definite assurances which would enable them to continue their assistance to the trade.

The decision of the association is on the whole regarded as wise, in view of the close connection between the interests of the producers and those of the large distributors. The disorganization of the market by the sale of nitrate at low prices when there were in existence large stocks purchased at much higher prices would react unfavorably upon the entire industry. On the other hand, the fear has been expressed that the maintenance of comparatively high prices might stimulate the competition of other fertilizers and curtail the consumption of Chilean nitrate. The current price is at least 2s. 6d. below the figure of 14s. announced by the Association, but there are no very large quantities on the market. The probable effect of the association's announcement will be a postponement of the hopes for an improvement in the nitrate market until a considerable part of the large stocks now existing have been disposed of. It seems improbable that there will be any further sales until the beginning of the coming nitrate year on July 1, and the improvement of conditions may be delayed even longer unless business conditions in the United States and Europe improve considerably before that time.

During the calendar year, 1920, the total nitrate shipments through the Panama Canal aggregated 1,995,906 tons, a monthly average of 166,325 tons. This was approximately one-third of the cargo moving through the Canal from the Pacific to the Atlantic. Reports from Chile and from London are not optimistic, and there appears to be little likeli-

hood that shipments will be resumed on a large scale within the immediate future.

NITRATE OF SODA STATISTICS (*a*)
(In tons of 2240 lb.)

Year.	Shipments from South America.	Consumed in Europe.	Consumed in United States.	Consumed in World.	Stocks in Europe.	Visible Supply at Close of Year. (*d*)
1905	1,623,000	1,190,000	308,000	1,547,000	183,000	674,000
1906	1,700,000	1,243,000	355,000	1,636,000	190,000	733,000
1907	1,626,000	1,252,000	350,000	1,658,000	202,000	695,000
1908	2,017,000	1,378,000	309,000	1,732,000	402,000	928,000
1909	2,100,000	1,465,000	407,000	1,938,000	337,000	999,000
1910	2,300,000	1,651,000	501,000	2,241,000	310,000	969,000
1911	2,412,000	1,696,000	550,000	2,355,000	479,000	1,058,000
1912	2,478,000	1,908,000	481,000	2,508,000	310,000	1,004,000
1913(*b*)	2,739,530	(*c*)2,008,010	(*c*) 630,698	(*c*)2,739,530	380,419	472,543
1914(*b*)	1,847,586	(*c*)1,198,367	(*c*) 540,143	(*c*)1,847,586	.....	1,070,721
1915(*b*)	2,031,014	(*c*) 999,739	(*c*) 850,978	(*c*)2,030,964	.....	777,223
1916(*b*)	2,991,786	(*c*)1,609,381	(*c*)1,226,816	(*c*)2,985,300	.....	694,968
1917(*b*)	2,787,322	(*c*)1,053,786	(*c*)1,512,577	(*c*)2,769,062	.....	882,556
1918(*b*)	2,930,664	(*c*) 857,590	(*c*)1,919,762	(*c*)2,919,030	.....	811,922

(*a*) Statistics of W. Montgomery & Co., London. (*b*) Metric tons. Statistics of the International Institute of Agriculture, Rome. (*c*) Consignments from Chile. (*d*) On Chilean coast.

United States Imports of Nitrate.—The imports of Chile saltpeter into the United States over a period of 7 years, as shown by the Government records, were as follows:

	Long Tons.	Value.	Price per Ton.
1913	625,862	$21,630,811	$34.54
1914	541,715	15,228,671	28.22
1915	772,190	22,959,997	29.73
1916	1,218,423	38,131,962	31.30
1917	1,543,213	60,437,526	39.16
1918	1,845,074	90,360,207	48.97
1919	407,459	19,558,963	48.00
1920	1,321,922	63,129,196	47.76

The visible supply of nitrate early in 1921 reached 2,102,000 tons, composed as follows: 1,252,000 tons from Chile, 492,000 in Europe, 277,000 in the United States and 81,000 in Japan and other countries.

The fertilizer industry of the United States and Europe will doubtless be served in the future at an increasing rate by the synthetic nitrate plants, which may have a marked effect on the price of Chilean nitrate. The proposal of private interests to take over the United States plant at Muscle Shoals, Ala., the release of German nitrates for export and the cheaper processes for fixing nitrogen developed in Italy and America all indicate a trend in this direction. This will not work disaster to the Chilean product because of its popularity with the American farmers as an ingredient for mixed fertilizers, but should have a healthy competitive effect on the present companies shipping the natural product. Cheaper methods of extraction must be sought out and restraint of trade through curtailment of production must be lifted.

Soda Ash

Soda ash is the commercial term used for normal sodium carbonate without water of crystallization (Na_2CO_3, theoretically Na_2O, 58.49 per cent., CO_2, 41.51 per cent.). It is supplied commercially in various grades, such as 58 and 48 per cent., ordinary ,or dense. The percentages refer to content of soda (Na_2O). The 58-per cent. ash is the highest grade and contains about 99 per cent. of Na_2CO_3. The distinction between the ordinary and the dense grades is merely one of density; the dense variety is preferred by glass-makers.

United States.—The soda ash produced and marketed as such in the United States in the calendar year 1919 amounted to 981,054 short tons, valued at $29,895,343, as compared with 1,390,628 short tons, valued at $35,635,520, in 1918. These figures do not include sodium carbonate reported in the form of monohydrate and sesquicarbonate nor the soda ash consumed where it was made in the manufacture of caustic soda and other sodium compounds. The quantity of soda ash so consumed in 1918 was about 664,000 short tons; corresponding figures were not collected in 1919.

The manufacture of soda ash for sale in the United States is confined almost entirely to New York, Ohio, Virginia, Michigan, California, and Kansas.

The following is a list of the producers of soda ash in 1919:

Columbia Chemical Co., Pittsburgh, Pa.
Diamond Alkali Co., Pittsburgh, Pa.
Mathieson Alkali Works (Inc.), 25 W. Forty-third St., New York, N. Y.
Michigan Alkali Co., Wyandotte, Mich.
Solvay Process Co., Syracuse, N. Y.
California Alkali Co., Hellman Bldg., Los Angeles, Calif.
Natural Soda Products Co., Keeler, Calif.

Of these seven companies the first five manufacture their material from salt brine; the last two have deposits of the natural salt.

The imports of sodium carbonate for consumption in the United States in 1920 amounted to 761 tons, valued at $37,844, compared with 415 tons valued at $12,998 in 1919. The exports of soda ash in 1920 amounted to 8,338 short tons, valued at $4,689,591.

Sodium carbonate in the form of soda ash is the foundation of the alkali industry, for it is used in the manufacture of glass, soap and dyes, as well as of caustic soda and most other sodium compounds. It is second only to lime and limestone in cheapness and general applicability as a base. It is used directly in making glass and after conversion into sodium hydroxide or other sodium compounds it is used in nearly all the

chemical industries, especially in making soap, wood-pulp, paper, dyes, explosives, bleach-liquor, and cleansing preparations and in tanning.

Sodium Sulphate

United States.—The scarcity of sodium sulphate as a by-product in the manufacture of hydrochloric acid from salt and the unsatisfactory natural production in volume and deliveries, together with the great demands of the soda pulp and glass industries for salt cake resulted in a spectacular market advance in this commodity and encouraged search throughout the west and southwest for deposits of natural Glauber's salt or mirabilite.

The chief sources were the vast Carrizo Plains deposits in San Louis Obispo County, California, certain clay deposits in Arizona and New Mexico, and a small quantity from Nevada and Utah.

A survey of the total data indicated the superiority in purity and accessibility of the product of the Wyoming fields. Closer study indicated the commercial possibilities of the Downey Lakes deposits, 13 miles southwest of Laramie, Wyo., where approximately 4,000,000 tons of the natural salt rest in dry and semi-dry lakes.

Laboratory tests of this material conducted throughout the summer of 1920, at the University of Wyoming, indicated a Na_2SO_4 content in excess of 95 per cent. in the calcined product. The crystals ran 44 per cent. Na_2SO_4, iron-free, and with trace only of the chlorides of lime and magnesia.

At the elevation of the deposits, 6000 ft. above sea-level, the dryness quickly effects efflorescence on exposure, resulting in a product flour-like in color and fineness over the area of the lakes during the dry season from March to November.

While cheap trucking is practicable owing to the absence of grades, the proximity of the Downey Lakes to the Union Pacific Railroad, nine miles distant, encourages the early construction of a spur track from the deposits to the main line.

For some time past, the existence of sodium sulphate around the shores of the Great Salt Lake has been known, and the Midwest Dye & Chemical Co. has been producing Glauber's salt ($Na_2SO_4.10H_2O$) and salt cake at its plant about two miles southwest of the Garfield smelter. A chemical analysis of the sodium sulphate showed the following results:

	Per Cent.
Sulphate, SO_4	63.87
Chloride, Cl	3.64
Magnesium, Mg	0.24
Calcium, Ca	0.36
Potassium, K	0.15
Sodium, Na	31.37
Total	99.63

Overlying the deposit, the extent of which has not been determined at either the south end or the north end of the lake, is 18 to 24 in. of sand, with some boulders. The overburden is easily removed, exposing the sodium sulphate, which is hard and crusty, and contains about 50 per cent. sand. The deposit itself is from 5 to 7 ft. thick. After removing the sand overburden, live steam is injected into the deposit by means of an open-end pipe. The heat causes the salt to go into solution very rapidly, and practically all of the sand settles to the bottom of the deposit. When sufficient solution is accumulated it is pumped into a small storage-tank, where additional settling takes place. This solution is then decanted and stored in shallow evaporating ponds. As the solution cools, crystals of Glauber's salt form.

A deposit of anhydrous sodium sulphate has been purchased by Western Chemicals, Inc., of Tonopah, Nev., development of the deposit having located considerable quantities of 95-per cent. sodium sulphate which can be removed by mining methods and put on the market as dug. The deposit is located about 23 miles south of Clarkedale, Ariz., to which place the material is now being hauled by truck.

Canada.—Another deposit of natural salt has been located in southern Saskatchewan, which on analysis, as reported, shows from 98 to 99 per cent. of sodium sulphate, with a slight trace of common salt and potash. The deposit is situated in townships 4, R. 21, W. 2nd, and lies in the form of a lake bed about four miles in length, and from 200 to 900 yd. wide. Drilling has been carried on, so far, to a depth of 16 ft. The deposit is, apparently, something similar to the one at Muskiki Lake. While full investigations have not been made, it would appear that the possibilities for obtaining large quantities of sodium sulphate from the deposit are good.

Sweden.—There is a demand in Sweden for sodium sulphate, the paper manufacturers generally being in need of supplies. If American manufacturers of chemicals can promptly satisfy the present demand at reasonable prices a steady market will be assured, according to the U. S. Department of Commerce. The Swedish Paper Mills Association of Stockholm uses on an average 40,000 tons of sodium sulphate per year, and the manufacturing director states that orders will undoubtedly be forthcoming as soon as sure sources of supplies are found.

Wood-pulp for paper manufacture is likewise an important and flourishing Swedish industry, its future being assured by the vast timber supply of the country. In 1919 there were 807,761 tons of wood-pulp exported from Sweden, the value of which was $13,649,000. The wood-pulp industry is likewise in need of a steady supply of sodium sulphate, the home manufacture being by no means sufficient to meet the demand.

SULPHUR, PYRITE AND SULPHURIC ACID

By A. E. Wells

Sulphur

Until 1904, the production of sulphur in the United States was considerably less than 10,000 tons per year, and the bulk of the requirements had to be imported from Sicily. From 1904 to 1912, the United States produced just about enough for its own use, the imports from Sicily becoming less and less, and during the last few years have been practically nil. In 1912, the production in the United States was about 790,000 long tons, which exceeded the production of Italy. The sulphur companies began to build up a sulphur reserve in 1912 and 1913, and by 1917, when the United States entered the war, there were approximately 1,000,000 long tons on hand.

SULPHUR PRODUCED AND SHIPPED IN THE UNITED STATES (U. S. Geol. Survey)

Year.	Mined.	Shipped.		Year.	Mined.	Shipped.	
	Quantity, Long Tons.	Quantity, Long Tons.	Approximate Value.		Quantity, Long Tons.	Quantity, Long Tons.	Approximate Value.
1909.....	273,983	258,283	$4,783,000	1915....	520,582	293,803	$3,955,000
1910.....	247,060	250,919	4,522,000	1916....	649,683	766,835	12,247,000
1911.....	205,066	253,795	4,573,000	1917....	1,134,412	1,120,378	23,987,000
1912.....	787,735	305,390	5,289,000	1918....	1,353,525	1,266,709	27,868,000
1913.....	491,080	319,333	5,614,000	1919....	1,190,575	678,257	10,252,000
1914.....	417,690	341,985	6,214,000	1920....	1,255,249	1,517,625	30,000,000

The United States, having a productive capacity of considerably over 2,000,000 tons per year, now dominates the sulphur industry of the world.

Virtually all the sulphur production has come from the Union Sulphur Co.'s mine at Sulphur, La., the Freeport Sulphur Co. at Freeport, Texas, and the Texas Gulf Sulphur Co. at Matagordo, Texas—all situated in the Gulf Coast regions of Louisiana and Texas.

A number of other localities in western Texas, Colorado, Wyoming, Idaho and Nevada have surface deposits, usually of limited extent, which have been worked on a small scale, but which have declined in

importance with the development of the better grades and more accessible deposits of the Gulf Coastal region.

More than twenty of the "saline domes" have been located along the coastal plain, scattered over an area about 200 miles in length, extending through western Louisiana and eastern Texas and generally within 50 miles of the Gulf of Mexico.

The sulphur occurs at a depth of 300 to 1200 ft., and is associated with limestone and underlain by gypsum. The surface area of the producing domes varies from 200 to 1500 acres. Exploration is done by drilling at a cost of $200,000 to $300,000, and the cost of a complete plant is several million dollars. The sulphur cannot be mined by shafts, owing to the quicksands and the poisonous gases encountered. The deposit at Sulphur, La., remained unworked for almost 40 years after its discovery before a satisfactory process was developed to mine it. This is known as the "Frasch process," and consists of the sinking of wells to the sulphur deposit, each well being lined with a 10 to 12-in. pipe. Smaller pipes are placed inside, so that superheated water can be brought in contact with the sulphur ore, which is melted and forced to the surface by compressed air. The sulphur on cooling is ready for market and is over 99 per cent. pure.

Each of the three plants in operation is equipped with a boiler capacity of over 20,000 hp. for superheating the water, and requires about a million and a quarter barrels of fuel oil per year. The origin of these domes is believed to be due to deep-seated igneous intrusions, resulting in the alteration of gypsum and the crystallization of salt and sulphur which has caused an upbowing of the strata. Because of the nature of the formation and the irregularity of the deposits it is impossible accurately to estimate the reserves of sulphur.

Commercial deposits of petroleum and salt have been developed in connection with the domes, but so far not more than one of the substances sulphur, salt or petroleum have been developed to a commercial degree in a single dome.

The operation of the Texas Gulf Sulphur Co. is the most recently started. Production was not started until March, 1919, but since that time the production has been practically continuous. The plant of this company was designed to have a capacity of 1000 tons of sulphur per day, but for a month at a time during the last year the production has exceeded 2500 tons per day. Under a favorable market the possible daily production could be forced to 3000 to 4000 tons per day, which was about the maximum production attained by the Union Sulphur Co. in 1918.

It is estimated that the deposit of the Texas Gulf Sulphur Co. contains upward of 10,000,000 tons of sulphur. The main deposit has a diameter

of about 4000 ft. and is situated 800 to 1000 ft. below the surface of the ground. The sulphur occurs in an almost flat stratum whose general shape is like that of a flat-topped umbrella. Above the sulphur stratum is an unconsolidated sediment consisting of bands of shale, gumbo and boulders. Below is a layer of salt and gypsum, and then a layer of salt of undetermined but very considerable thickness.

At the time the Texas Gulf Sulphur Co. entered the market, the situation was about as follows: The Union Sulphur Co. had on top of the ground an unsold stock of sulphur, upward of one million tons, and the Freeport Sulphur Co. had several hundred thousand tons. The normal consumption of sulphur in the United States had been between four and five hundred thousand tons per annum, which quantity could be readily supplied by the two older companies. A new sulphur company entering the market with a large production of sulphur was therefore compelled to pursue one of two policies—either to attempt to obtain a share of the business by cutting prices or to place the sulphur in markets which had not hitherto used sulphur; in other words, to increase the sulphur consumption of the country.

The mining of sulphur by the Frasch process, to be carried out economically, must be conducted on a very large scale, so that even if a company under the conditions outlined above had obtained a third of a possible 500,000-ton consumption, this would not have insured profitable operation. The company has chosen what is surely the wiser course, in attempting to place its sulphur by increasing the total consumption in the industries.

It was possible to do this owing to the prevailing economic conditions. The United States had in recent years consumed annually, for the manufacture of sulphuric acid, upward of 500,000 tons of sulphur in the form of pyrite, most of which came from Spain. The older sulphur companies, either because of some agreement with the pyrite importers or because of a desire to hold the price of sulphur at a certain level, had not attempted seriously in past years to substitute sulphur for pyrite as the raw material of sulphuric-acid manufacture. Importation of Spanish pyrite, due to war transportation conditions, fell off very seriously during the war years. This caused many producers of sulphuric acid to discard the pyrite roasters and to install sulphur-burning equipment, while new acid producers erected plants which were almost entirely so equipped.

The new company was able to obtain a large proportion of the new business, with the net result that the total consumption of sulphur in the United States during the year 1920 has been close to 1,000,000 tons, as compared with a normal consumption of less than half that amount prior to the war.

With the general curtailment of industries during the latter half of 1920, the demand for sulphur greatly decreased, and operations of the Union Sulphur Co. and the Freeport Sulphur Co. were greatly curtailed. In April, 1921, the Freeport Sulphur Co. closed down for an indefinite period.

Sulphur is today one of the few substances which have not risen in price since pre-war days. In fact, sulphur is cheaper today than at any other time in the history of the industry. The price for large contracts is about $20 per ton, Atlantic seaboard. This makes sulphur one of the cheapest raw materials available and should, it would seem, greatly extend its usefulness. Sulphur as mined and sold by all three companies is of remarkably high grade. The sulphur is free from arsenic, selenium and tellurium, and often for days at a time wells will yield a product running higher than 99.9 per cent. sulphur, as calculated on a moisture-free basis; in fact, sulphur companies selling the crude sulphur on contracts guarantee the purity to be over 99 or 99½ per cent.

Imports and Exports

The only foreign sulphur which normally enters the American market in quantity comes from Japan, and its percentage calculated on the consumption of the United States is small and is not likely to increase. Rising costs of living have meant much higher wages in Japan, as well as in other parts of the world; in fact, the percentage increase has probably been greatest in Japan, due not only to world conditions affecting all countries, but to the rising standards of living of the Japanese. These facts, together with present higher transportation costs, will make it increasingly difficult for Japanese sulphur to compete on our Pacific Coast with the American product. Exports were the largest on record, amounting to 477,450 tons.

SULPHUR IMPORTS AND EXPORTS OF THE UNITED STATES
(In tons of 2240 lb.)

Kind.	1916.		1917.		1918.		1919.		1920.	
	Amt.	Value.	Amt.	Value.	Amt.	Value.	Amt.	Value.	Amt.	Value.
Imports:										
Crude	21,510	$364,787	973	$20,176	55	$1,692	77	$1,997	46	$1,722
Flowers	425	15,408	.....	.....	.....	.....	.....	.....	.....	.....
Refined	455	15,020	.....	.....	.....	.....	.....	15	50	..2,530
Precipitated	66	12,940	37	9,164	27	7,850	24	6,621	42	..22,576
Total imports	22,456	$404,784	1,010	$29,340	82	$9,542	103	8,633	138	..26,828
Exports	128,755	2,505,857	152,736	3,500,819	131,092	3,626,638	224,712	6,325,552	477,450	8,994,350

WORLD'S PRODUCTION OF SULPHUR (a)
(In metric tons)

Year.	Austria. (b) (e)	Chile.	France. (b)	Germany.	Greece.	Italy. (b)	Japan.	Spain.	United States. (g)	Total.
1903	4,610	3,560	7,375	209	1,266	553,751	22,914	1,680	35,660	631,035
1904	6,431	3,594	5,447	205	1,225	527,563	25,587	605	196,588	767,249
1905	8,542	3,470	4,637	178	1,126	568,927	24,652	610	218,440	830,609
1906	15,258	4,598	2,713	176	(d)1,000	499,814	27,589	700	298,704	845,956
1907	24,199	2,905	2,000	811	(d)1,000	426,972	33,329	3,612	312,731	801,91
1908	17,429	2,705	2,189	1,185	(d)1,000	445,312	33,419	13,872	312,700	829,437
1909	12,856	4,508	2,900		(d)1,000	435,060	36,317	21,750	303,000	817,608
1910	15,976	3,823	2,641	1,272	.....	430,360	43,848	30,113	259,699	787,732
1911	15,856	4,451	1,200	1,251	174	414,671	52,064	40,662	246,300	776,629
1912	14,979	4,431	1,000	(c)	2,016	357,547	55,005	42,344	308,530	785,852
1913	10,561	6,647	659	.....	*Nil.*	386,310	59,481	62,653	316,783	806,386
1914	20,314	10,008	.....	.....	*Nil.*	377,843	75,308	47,180	347,491	(f)877,000
1915	3,180	9,767	388	.....	*Nil.*	358,107	73,369	28,937	299,133	(f)860,000
1916	.....	14,876	700	.....	*Nil.*	269,374	108,100	46,923	779,181	1,219,104
1917	.....	18,938	704	.....	*Nil.*	211,847	117,990	84,979	1,138,416	1,572,874
1918	.....	19,553	4,200	.....	.....	234,296	64,696	72,360	1,287,103	1,682,208
1919	.....	.....	.....	.....	.....	226,126	.....	89,586	680,800	.. ....

(a) From the official reports of the respective governments. The sulphur recovered as a by-product by the Chance-Claus process in the United Kingdom, amounting to between 20,000 and 30,000 long tons annually, is not included. (b) Crude mineral; limestone impregnated with sulphur. (c) Not yet reported. (d) Estimated. (e) Includes such production from Hungary. (f) Totals estimated by the International Institute of Agriculture, Rome. (g) Shipped from mines.

Foreign Countries

France.—Following are the sulphur exports and imports of France for 6 years, in metric tons:

Year.	Exports.	Imports.
1915	11,608	99,395
1916	17,301	128,095
1917	5,532	76,866
1918	8,652	71,886
1919	4,051	139,958
1920	30,460	237,912

Italy.—The total production of sulphur in Sicily in 1919 amounted to 181,374 metric tons, a decrease of 14,011 tons as compared with the preceding year. Exports of raw sulphur during the year were 147,775 tons, a decrease of 83,014 tons over 1918. Stock on hand on Dec. 31, 1919, amounted to 136,859 tons, an increase of 24,809 tons over 1918. There has been a gradual decrease in the production in this industry during the last decade, because of the competition of American sulphur in the world markets. Consumption in Italy was also kept at a minimum because of the general economy being exercised in the use of this commodity in the vineyards.

Prices gradually increased throughout the year as a result of the lack of labor, the increased cost of production, and the fluctuations in exchange. All prices for this commodity for the export trade are quoted in English sterling, and at the end of the year ranged from 210 to 300 shillings per metric ton f. o. b. Sicily, for the best two-thirds unmixed in bulk and the ground "flori stella" in bags, respectively. According to reliable sources it may be possible for the United States to compete

successfully in selling sulphur in the Mediterranean as soon as a reduction in ocean freights occurs.[1]

It is not strictly correct to imply that Italy's sources of sulphur supply are limited to the island of Sicily. There is a district on the Adriatic near the cities of Rimini and Pesaro where sulphur is mined. One small mine is in operation on the east coast of southern Calabria. The amount of sulphur produced on the mainland, however, amounts to only about 10 per cent. of the total for all Italy.

TOTAL EXPORTS OF SULPHUR FROM SICILY
(In metric tons)

Country.	1913.(*d*)	1914.(*d*)	1915.(*d*)	1916.(*a*)	1917.(*a*)	1918.(*a*)	1919.(*d*)	1920.(*d*)
Austria	36,335	25,306	70	.....	.....	.....	137	736
Belgium	13,321	5,975	.....	.....	.....	.....	2,152	3,711
France	21,582	60,773	96,156	107,311	68,565	90,376	69,072	37,163
Germany	31,042	18,826	391	.....	.....	.....	590	4,784
Greece and Turkey	20,112	20,746	19,857	15,384	3,893	7,590	18,826	10,895
Holland	8,976	8,080	1,163	524	.....	.....	1,119	1,207
Italy	85,740	97,170	116,601	76,502	53,748	43,631	32,015	55,035
Portugal	21,445	17,604	21,004	13,994	5,749	12,480	7,876	32,017
Spain				8,127	2,017			
Scandinavia (*c*)	28,108	25,294	24,832	26,450	2,500	1,769	1,701	6,412
Russia	25,891	21,290	2,791	19,947	6,578	.....	306	61,433
United Kingdom	16,052	12,991	36,156	68,849	20,114	62,595	3,689	11,698
United States	1,028	1,406	2,054	612	.....	.....	.....	165
Other countries(*b*)	54,185	22,883	38,731	62,440	4,213	12,263	9,803	24,624
Totals	414,717	338,344	359,806	396,035	168,487	230,769	147,286	189,878
Stock in Sicily, Dec. 31	376,365	369,001	274,069	155,376	158,812	111,914	136,991	147,886

(*a*) Statistics of the International Institute of Agriculture, Rome. (*b*) Mainly South Africa, Northern Africa, Asia, Australia, and the East Indies. (*c*) Including Norway, Sweden and Denmark. (*d*) Reported by Parsons & Petit, New York.

The total Italian production for the past few years is as follows:

	Metric Tons.
1913	386,310
1914	377,843
1915	358,107
1916	269,347
1917	211,847
1918	234,296
1919	226,126
1920	258,000

Norway.—The following table shows the imports and exports of sulphur by Norway from 1910 to 1919, inclusive, in metric tons:

Years.	Imports.	Exports.	Years.	Imports.	Exports.
1910	10,279	618	1915	6,804	41
1911	8,782	166	1916	7,262	.....
1912	13,911	1,003	1917	4,071	.....
1913	15,411	117	1918	3,036	.....
1914	10,347	334	1919	54	.....

[1] *Am. Fert.*, Jan. 15, 1921.

It is reported that rich sulphur fields have been discovered at Kongsvold, western Norway. They extend over 1500 square miles, and are estimated to contain 8,000,000 tons of excellent sulphur.

Technology

Use of Sulphur in Manufacture of Sulphuric Acid.—For sulphuric-acid manufacture sulphur has several marked advantages over pyrite. Using pyrite means handling in the works a comparatively large quantity of material, its slow combustion in expensive roasters, a certain inevitable dust nuisance and the disposal of a large tonnage of cinder. As against this, sulphur of less than one-half the weight of pyrite for a given tonnage of acid produced is handled in the works, is burned cleanly in inexpensive equipment, and leaves no residues to be taken care of. Sulphur is constant in composition, and its freedom from arsenic and other impurities allows the production of a purer acid. In practice, the burning of sulphur means a higher rate of production for a given size of lead-chamber space.

These acknowledged advantages of the use of sulphur over pyrite for sulphuric-acid manufacture have been demonstrated by the willingness of acid producers to pay a higher price per unit for elementary sulphur than for combined sulphur in the form of pyrite.

Effect of Petroleum.—One impurity occurring in traces in the sulphur of all three companies is oil.[1] There is a dearth of information in the technical literature respecting the subject of oil in sulphur. Since the effect of this impurity is very interesting, it is appropriate to discuss it here. The peculiar effect of oil is its influence on the burning qualities and also on the color and odor of sulphur. *A priori*, one would not assume that mere traces of a combustible substance like petroleum could affect adversely the combustion of another combustible substance like sulphur, but such is indeed the case.

If one will make a simple experiment by attempting to burn two small lots of sulphur, one being chemically pure and the other containing 0.2 per cent. of petroleum oil, he will note the following phenomena: The pure sulphur will burn quietly until it is totally consumed; the sulphur containing the oil will burn for a very short time, when it will be observed that a thin, elastic film is being formed over its surface. Very soon combustion is taking place only in spots, and within an exceedingly short time the flame goes out, although only a small percentage of the sulphur has been consumed. The explanation is quite simple. Sulphur and oil at a moderate temperature react together to form asphalt, and if the reaction is carried to completion the final result is carbon.

In the burning of sulphur containing oil the oil reacts with the sulphur

[1] Raymond F. Bacon and Harold S. Davis, *Chem. Met. Eng.*, Jan. 12, 1921.

to form an asphaltic material, which quickly spreads as a film over the surface. The result, as combustion proceeds, is a film of carbon over the surface of the sulphur. The ignition temperature of carbon, or of the intermediate asphaltic material, is so much higher than that of sulphur itself or than the temperature developed during the burning of the sulphur that this film is not ignited and consequently the whole flame is extinguished.

The remedy for burning such sulphur is also quite obvious. If the devices for sulphur combustion are such as to agitate the surface of the burning sulphur or in any other way break this film of asphaltic material, no difficulty will be experienced. Acid manufacturers who use mostly modern types of sulphur burners, such as the rotary or cascade type, which allow the sulphur to drop from one level to another, have absolutely no difficulty in burning sulphur containing 0.2 per cent. of oil, which figure represents more oil than any of the commercial sulphurs contain at the present time. On the other hand, many of the small paper-pulp manufacturers still adhere to types of burners in which the burning sulphur is more or less quiescent. With such a type there is no agitation of the burning liquid surface, so that some of these paper-pulp manufacturers have had difficulty in burning sulphur when they happened to obtain a shipment comparatively high in oil.

The sulphur deposits of all three operating companies are located in close proximity to oil fields. When a sulphur deposit is first opened some of the product may be high in oil, running as much as 0.2 per cent., but as production proceeds the oil becomes progressively lower until finally, for days at a time, it may amount to only 0.04 per cent., which is totally negligible, even for burners which provide no agitation of the surface. We have assumed that hot water carried this small quantity of oil from small crevices in the oil-sand formation to the sulphur below when the well was first opened. After a region has become heated up by the hot water, these traces of oil are pretty well washed out; consequently, sulphur mined later in the same area is virtually free from it. Examination of drill cores of native sulphur showed such *in situ* sulphur to be oil-free. This corresponds with the experiences of the Union Sulphur Co. in heating up any new area of sulphur ground. The examination of a very large number of samples of sulphur, representing the production of all three companies, has shown quite positively that none of their sulphur contains enough oil to cause any difficulty in its combustion with rotary burners or other burners which agitate the surface of the burning sulphur during combustion. It is only very exceptionally that one will find a car of sulphur whose oil content is high enough to make difficulties in its combustion in a stationary type of burner.

Sulphur as a Fertilizer.—One possible tonnage use for sulphur which has been arousing a great deal of interest in the last five years is its application as a fertilizer. There are two methods of application which have received attention from experiment stations. During the war, when sulphuric acid was needed for munition manufacture, Lipman, of the New Jersey Experiment Station, showed that if sulphur is composted with ground raw phosphate rock, the phosphate is rendered available within a reasonably short time. Bacteria in the soil oxidize the sulphur to sulphuric acid, which acts on the raw phosphate to give available plant food. It is thus possible to make available as high a percentage of phosphoric acid as is found in commercial acid phosphate. The work has been confirmed by other experiment stations and would undoubtedly have been of great importance if the shortage of sulphuric acid had continued. Lipman has since improved the procedure by isolating and growing pure cultures of the most active sulphur-oxidizing bacteria and has prepared sulphur inoculated with these.

The other use of sulphur as a fertilizer consists in its direct application to the soil. The Oregon Agricultural College Experiment Station has shown very conclusively that certain soils in southern Oregon are immensely benefitted in this way, so that the alfalfa crops have been greatly increased. Several of the other state experiment stations have reported the same experience for certain types of soils.

However, most of our soils either contain enough sulphur for plant requirements or receive sufficient in the rainfall and other water. There are also very many soils on which sulphur would undoubtedly prove to be an advantageous fertilizer either because of a deficiency in sulphur or because sulphur during its oxidation would make available from the soil other needed plant foods. Work is either under way or in project in almost every experiment station in the country to obtain more knowledge on this subject, especially to find out what soils in each particular state have need of sulphur. It is probable that in time this may mean a tonnage market for sulphur, but when it is considered that there is today definite proof that the farmers of the country as a whole could use to their own profit at least ten times as much fertilizer as they do it will be realized that the building up of a tonnage use of any new fertilizer promises nothing large in the near future.

The greatest problem of the American sulphur industry at the present time is to obtain immediately available new tonnage outlets for sulphur. The solution of this problem would mean a continued prosperity to the sulphur industry and a continuance of low-priced sulphur for the greater chemical industry.

Pyrite

The production of pyrite in this country has fallen off greatly since the Armistice. In fact, only a few very favorably situated deposits are now being worked.

This falling-off in production is due to the low price at which brimstone is being sold to the sulphuric-acid plants, and also to the competition of Spanish pyrite on the Atlantic seaboard. The future of the domestic pyrite producer does not appear bright in the face of the brimstone and Spanish pyrite competition. Only those mines immediately adjacent to consuming plants can meet the present situation.

PRODUCTION, IMPORTS AND CONSUMPTION OF PYRITE IN THE UNITED STATES (a)
(In tons of 2240 lb.)

Year.	Production.		Imports. (b)		Consumption.	
1906	225,045	$767,866	597,347	$2,138,746	822,392	$2,906,612
1907	261,871	851,346	656,477	2,637,485	918,348	3,488,831
1908	206,471	744,463	668,115	2,624,339	874,586	3,368,802
1909	210,000	756,814	692,385	2,428,638	902,385	3,185,452
1910	223,700	830,150	806,590	2,773,627	1,303,402	3,603,777
1911	301,458	1,164,871	1,001,944	3,788,632	1,301,848	4,953,503
1912	350,928	1,334,259	964,478	3,860,738	1,315,406	5,194,997
1913	341,338	1,286,284	850,592	3,611,136	1,192,930	4,897,421
1914	336,662	1,283,346	1,026,617	4,797,326	1,363,279	6,080,672
1915	394,124	1,374,933	964,634	4,817,977	1,358,758	6,492,910
1916	439,132	2,038,002	1,244,519	6,728,318	1,683,651	8,766,320
1917	482,662	2,593,035	967,340	5,980,457	1,450,002	8,573,492
1918	464,494	2,644,515	498,786	2,767,448	963,280	5,411,963
1919	420,647	2,558,172	388,973	2,176,565	809,620	4,734,737
1920	275,000	1,450,000	332,606	1,660,832	607,606	3,110,832

(a) U. S. Geological Survey. (b) Net imports, less re-exports.

Incidentally, one of the objections to the use of domestic pyrite is the fact that the ore when mined frequently produces more fines than lumps. An average proportion is about two-thirds fines to one-third lump. As the greater portion of the Southern acid plants are equipped to handle furnace ore, this interposes some difficulty in manipulation. Sulphuric-acid manufacturing equipment in the north consists principally of fines burners. Concentration is frequently necessary to make the ore sufficiently high grade to treat. The average eastern domestic pyrites, lump, fines, and concentrates, runs about 40 per cent. sulphur, which is lower than the imported Spanish grades, and is usually very low in phosphorus and arsenic. A small percentage of copper is frequently present. Domestic fines and concentrates have the advantage of usually being easier to roast than the Spanish fines.

The bituminous-coal mines of certain districts have long furnished a small tonnage of pyrite in the form of coal brasses. A mechanical concentrator at Danville, Ill., for a number of years has been treating hand-

picked lump pyrite and coal from the picking belt and from the mines, and a small plant near Gillespie, Ill., for a few months has been recovering pyrite from washery refuse.

Many mines throughout Illinois, Indiana, western Kentucky, Ohio, and Pennsylvania have shipped an occasionl car of the hand-cleaned lump pyrite. Only a small percentage of the available pyrite has been recovered in this way, however, as usually the miners throw such lumps into the gob with slate and other impurities. It has been estimated that the western Indiana coal field could furnish annually more than 100,000 tons of pyrite. The present production is small, and although the possibility of furnishing the domestic trade with pyrites recovered as a by-product from coal-mining operations appears attractive, there are certain features that are difficult to overcome.

The recovery of pyrite from coal will not be extensively practiced, it is felt, so long as the Louisiana brimstone can be obtained at present or pre-war prices. The acid plant that uses pyrite must have a greater investment in burning and dust-settling equipment than if brimstone is used. It is true, however, that at certain points farthest removed from the source of supply of brimstone, and near the coal fields, coal pyrite can be used advantageously.

Ever since 1891 the total yearly imports of pyrites from all countries has been greater than the domestic production. During the greater part of this period imports have been more than twice the domestic output, indicating clearly the important part played by importers in the pyrites industry. It has only been in the last few years, in 1918 to 1920, that imports have taken a decided downward slump, so that domestic production and imports nearly balance.

The following table shows the source of the monthly receipts of pyrite during 1919 and 1920, in long tons.

	1919.			1920.		
	Spain.	Canada.	Total.	Spain.	Canada.	Total.
January	4,662	1,760	6,422	10,263	1	13,114
February	.....	1,053	1,053	33,180	.....	37,117
March	9,944	1,765	13,959	14,251	.....	14,251
April	22,074	1,675	25,294	19,005	77	21,882
May	29,951	420	33,263	17,629	7.700	25,329
June	46,787	3,158	50,545	27,640	26,775	54,415
July	37,099	24,889	62,088	34,874	21,879	56,753
August	21,275	9,430	30,705	18,201	16,940	48,832
September	20,583	8,061	28,658	883	10,700	14,433
October	42,707	19,548	67,141	11,308	5,600	16,908
November	22,744	11,865	40,259	.....	5,600	8,600
December	22,289	537	29,586	12,472	5,400	20,972
Total	280,725	84,761	388,973	200,706	100,672	332,606

During the year 1920, the importation of Spanish pyrite was greatly curtailed because of the long-continued labor difficulties in Spain. The total imports for the year 1920 were 332,606 tons.

WORLD'S PRODUCTION OF PYRITE
(In metric tons)

Year.	Belgium.	Bosnia.	Canada.	England.	France.	Germany.	Greece.	Hungary.	Italy. (a)
1906..	908	13,474	35,927	11,318	265,261	196,971	*Nil.*	112,623	122,364
1907..	397	3,671	35,494	10,357	283,000	196,320	*Nil.*	99,503	126,925
1908..	357	10,403	42,934	9,599	284,717	219,455	6,868	95,824	131,721
1909..	214	7,266	58,645	8,564	273,221	198,688	14,740	98,971	149,084
1910..	213	571	48,871	10,393	250,432	215,708	33,294	92,464	165,688
1911..	122	3,118	74,978	10,276	277,900	217,459	35,960	96,754	165,273
1912..	148	6,216	73,944	10,691	282,202	242,121	29,766	103,809	277,585
1913..	268	3,242	143,882	11,611	311,167	268,600	128,880	106,629	317,334
1914..	109	4,459	204,125	11,848	199,326	232,300	129,150	102,370	335,531
1915..	129	(b)	259,494	10,711	196,606	641,600	12,113	(b)	369,320
1916..	212	9,255	280,552	10,656	219,371	(b)	19,938	(b)	410,290
1917..	81	2,803	377,984	8,652	280,797	(b)	9,535	(b)	500,782
1918..	6	(b)	373,418	22,552	260,310	(g)817,883	12,433	(b)	482,060
1919..	60	(b)	161,016	7,455	118,703	(g)348,585	(b)	(b)	372,574
1920..	*Nil.*	(b)	168,528	6,796	131,412	(b)	2,599	(b)	318,050

Year.	Japan.	Newfound-land.	Norway. (c)	Portugal. (c)	Russia.	Spain.	Sweden.	United States.	Total.
1906..	36,038	28,583	197,886	350,746	20,660	189,243	21,827	228,646	1,832,475
1907..	56,166	28,000	236,038	241,771	18,316	225,830	27,000	266,061	1,854,849
1908..	33,867	(e)35,000	269,129	81,417	56,345	263,457	29,569	209,774	1,780,436
1909..	27,066	*Nil.*	282,606	284,735	46,078	236,000	16,104	213,371	1,915,353
1910..	78,418	*Nil.*	322,000	312,906	55,980	294,184	25,445	227,280	1,860,148
1911..	73,879	2,500	350,000	282,773	113,054	344,879	30,096	304,974	2,383,995
1912..	74,929	*Nil.*	469,326	(f)601,443	123,990	421,070	31,835	356,707	3,105,782
1913..	114,589	.....	441,219	(f)391,083	e)130,000	926,913	34,319	347,027	3,636,478
1914..	115,842	.....	414,886	(a) 73,404	(b)	984,885	33,313	342,082	3,145,000
1915..	67,536	.....	513,335	(b)	(b)	802,383	76,324	399,469	.....
1916..	91,102	.....	295,354	(b)	(b)	953,679	97,848	446,202	.....
1917..	121,349	.....	328,694	(b)	(b)	976,918	142,660	490,433	.....
1918..	105,796	.....	(b)	(b)	(b)	590,008	141,181	471,972	.....
1919..	(b)	.....	(b)	(b)	(b)	431,189	108,770	427,419	.....
1920..	(b)	.....	(b)	(b)	(b)	(b)	(b)	279,427	.....

(a) Cupriferous in part. (b) Reports not yet available. (c) Both iron and copper pyrites. (e) Estimated. (f) Includes 120,148 tons copper iron pyrite in 1912 and 13,550 tons in 1913. (g) Prussia alone.

Foreign Countries

Canada.[1]—The shipments of pyrite as sulphur ore from Canadian mines have, during the past two years, been less than half those of 1918. The total shipments in 1920 were 174,744 tons valued at $751,009, and included 14,817 tons from Quebec, 148,652 tons from Ontario, and 11,275 tons from British Columbia. The total sulphur content of shipments was 67,627 net tons, or an average of 38.7 per cent. Of the total shipments 27,823 tons was sold for consumption in Canada and 146,921 tons for consumption in the United States.

In 1919 the total shipments were 176,487 tons valued at $522,704, and included 52,746 tons from Quebec, 117,011 tons from Ontario, and

[1] Prelim. Rept. Min. Prod. of Canada, 1920, Can. Dept. of Mines.

6730 tons from British Columbia. The total sulphur content was 65,674 tons, or an average of 37.2 per cent. Of the total shipments 43,754 tons was sold for consumption in Canada and 132,733 tons for consumption in the United States.

A change was made in the customs classification as from Mar. 1, 1920, covering exports of pyrites and sulphur. The recorded exports in 1920 included 30 tons of pyrites valued at $63 exported during the first three months and 119,106 tons of sulphur contained in pyrites valued at $458,340 exported during the last nine months. (The quantity appears to be incorrectly reported). In 1919 the recorded exports were 89,089 tons of pyrites valued at $388,508.

Spain and Portugal.—The extensive pyrite deposits of Spain and Portugal are the most important source of pyrite in the world, and account for over two-thirds of the world's production. Although practically a unit, Spain supplies 90 per cent. of the output of the district and Portugal the remainder. About two-thirds of the output contains copper in recoverable quantities. The higher-grade copper ore (containing over 5 per cent. copper) is smelted locally. A lower grade of copper ore containing 1½ to 5 per cent. copper is shipped to European countries for the recovery of its copper, sulphur, and iron content. Ores containing about 1½ per cent. copper are customarily treated locally for their copper content, and the residue, or "washed ore," containing pyrites, is exported to the United States. The lowest grade of ore, as judged by copper content, is shipped solely for its sulphur content.

The treatment of the 1½-per cent. copper ore is a leaching process utilizing water and atmospheric oxidation that extends over a period of three years.

The sulphur content of the Spanish pyrites imported to the United States varies between 45 and 50 per cent., the lump varieties usually running higher than the fines. A little arsenic may be contained in the ore. Most of the imported ore enters the country by way of New York, Philadelphia, and Baltimore, although the southern ports of Charleston, S. C., Savannah, Ga., New Orleans, La., Norfolk, Va., Jacksonville, Fla., and Wilmington, N. C., are also important domestic points of entry.

The Spanish ore comes in two principal grades, recognized by the trade as furnace size and fines size. Most of the ore of furnace size finds its way to the South, where furnaces for treating this sort of material almost exclusively are situated. The fines are consumed by the acid plants in the North. The price of the two grades ordinarily shows a differential of about 2 cts. per unit in favor of the furnace grade. This is due, as may be surmised, to the objectionable character of the extremely fine ore which the "fines" grade may contain.

Sulphuric Acid

Prior to 1918, the U. S. Geological Survey collected statistics as to the production of sulphuric acid in this country. The practice has been discontinued at least temporarily.

It is estimated that the total production of acid during 1920 was approximately 5,000,000 tons (basis 50° B.). The yearly production for 1911 to 1920 is given below.

Year.	Production. Tons, as 50° B. Acid.	Value.
1911	2,700,000	$17,369,872
1912	2,950,000	18,338,019
1913	3,575,000	22,684,526
1914	3,800,000	24,479,927
1915	4,120,000	32,657,051
1916	6,300,000	73,514,126
1917	7,200,000	87,540,181
1918	7,450,000	Not determined
1919	5,500,000 (est'd)	.....
1920	5,000,000 (est'd)	.....

The demand for sulphuric acid is a very sensitive barometer of the industrial conditions of the country. Thus the market for the acid during the latter half of 1920 was extremely dull, stocks were plentiful and prices weak.

Very little new construction was undertaken during the latter part of 1920.

Recent Development in Acid-making

The recent development of processes which use no chambers, but still use oxides of nitrogen, has upset the former classification of chamber process and catalytic processes. It is now proposed that these new processes shall be grouped with the chamber process under the general head "nitration processes," leaving the catalytic processes, as they were, in a group by themselves. One of these was the Kaltenbach pipe process in which the gas, after passing through the usual Glover tower, passes up a number of water-jacketed pipes, which are filled inside with a suitable packing material; and in these pipes the ascending gases come into direct contact with descending acid, admitted as a spray at the tops of the pipes, and cooled prior to admission. After passing through one group, or more, of these water-jacketed pipes, the gases are passed through a Gay-Lussac tower, which may itself, if desired, be a group of water-jacketed and packed pipes, for the recovery of oxides of nitrogen.

The other chamberless nitration process is the Anaconda packed cell process, the plant for which is called the packed cell plant. Such a plant has the conventional Glover and Gay-Lussac towers, but in lieu of lead chambers there is a series of towers, or "cells," built of acid-proof masonry in one block and the gases traverse these cells, going alternately downward, then upward, in their progress through the series. Each

cell of the series is fed at the top with a spray of acid, of the strength that is usually made in lead chambers, and previously brought to a predetermined desirable temperature. The last cell of the series is always fed with cooled acid. After leaving the last cell the gases pass into the usual Gay-Lussac tower for the recovery of oxides of nitrogen. The first plant had a capacity of 25 tons of acid per day, and was first operated in May, 1919. A 250-ton plant, for the same process, has been completely designed by the Anaconda Copper Mining Co., but construction has not yet started.

History of Sulphuric Acid Manufacturing in Canada Since 1895[1]

In 1895 the Victoria Chemical Co. of Victoria, B. C., established a chamber plant for the manufacture of sulphuric acid, concentrating to 66° B.

In 1901, a small chamber plant was started at Sydney, N. S., by the Dominion Coal Co., now the Dominion Iron and Steel Co., but was dismantled and replaced in 1911 by a large one, having Falding high chambers. This plant has a capacity of 50 tons per day of 50° B. acid and 5 tons per day of 66° B. acid.

In 1906 the chamber plant which had been erected at Capelton, Que., by the Nichols Chemical Co., was replaced by the contact system. Further contact plants were established at Sulphide, Ont., in 1907, and at Barnet, B. C., in 1908, by the same company. All of these contact plants have been in operation since their erection and are the only ones of this type in Canada at the present date.

About the year 1907 The Algoma Steel Corporation of Sault Ste. Marie installed a Falding high-chamber plant, as they required the acid to sulphate the ammonia in the coke-oven gas, and this plant is still in existence.

About the year 1909 a chamber plant was established at Hamilton by the Grasselli Chemical Co.; this plant concentrates to 66°.

In 1914 the Consolidated Mining and Smelting Co. of Trail, B. C., erected a small chamber plant to enable them to treat their zinc-lead ores and manufacture hydrofluosilicic acid, necessary in the refining of their lead, and this plant is still in operation.

During the war the Aetna Chemical Co. erected a chamber plant at Drummondville, Que., but this plant has not been operated since the war and is, it is reported, to be dismantled.

The British Chemical Co. built, during the war, a chamber plant at Trenton, Ont., but ceased operating when the war was over. A new company, Chemical Products, Ltd., has, however, been formed to take

[1] J. Bowner and A. Nieghorn, *Can. Chem. & Met.*

over and operate this plant, and will specialize in acidifying phosphate rock.

Thus there are five chamber plants operating in Canada, and two in position to operate. There are three contact plants.

The total production of sulphuric acid in Canada during the year 1920, expressed in terms of 66° Bé., was 82,811 short tons. The production during the first 6 months of the year was 38,891 tons and during the last six months 43,920 tons. The ores used in the manufacture of sulphuric acid included 13,534 tons of imported sulphur or brimstone and 16,679 tons of pyrites from Canadian sources containing an average of 37.6 per cent. sulphur.

Exports of sulphuric acid during 1920 were 10,033,900 lb., valued at $89,992, as against 10,894,200 lb. valued at $108,392 exported in 1919.

Imports of brimstone, or crude sulphur, in 1920, were 144,733 tons valued at $2,113,713, as compared with 56,062 tons, valued at $1,015,223, imported in 1919. Imports of sulphuric acid in 1920 were 320 tons valued at $22,664, as against imports of 1437 tons valued at $38,759 in 1919.

TALC AND SOAPSTONE

By Frederick B. Peck

The talc industry was active in 1920. The marketed production amounted to 198,549 short tons, valued at $2,311,841, exceeding the figures for any other year in value and any year except 1917 in quantity. Imports of talc were heavy, totaling 21,729 tons, with a value of $442,732. The largest total of imports in any previous year was 18,882 tons, in 1916, and the largest value was $269,497, in 1917. About 70 per cent. of the imported talc came from Canada, about 20 per cent. from Italy, about 8.5 per cent. from France, and the remainder from England, Austria, British West Indies, Denmark, Germany, and Sweden.

In the United States, Vermont easily leads in tonnage and possibly in value, with a production of over 94,000 tons, valued at over $830,000. New York stood second; but, although no figures are available, it is probable that production was not much larger than in 1918, when about 71,000 tons, valued at about $900,000, was mined. Though Vermont production is increasing, that of New York seems to be declining. Talc production in California was probably the largest ever reached. Several companies have been operating to capacity, and one company reports production increased from 3200 tons in 1919 to 8000 tons in 1920. Production in the South was small, but may show some increase over 1919.[1]

Prices on the average increased 10 to 15 per cent., individual companies reporting from 0 to 25 per cent. increases. Demand was strong until November, with orders unfilled owing to car shortage. Little new business was booked after November, many consumers withdrawing from the market and withholding contracts for 1921. Producers are now either stocking finished talc or working part time. Although some mill expansion is under consideration, the outlook for 1921 is uncertain. No general decline in quotations for talc in 1921 is looked for, as the prices of talc have not increased materially since 1914. The average value of talc in 1920 was only about 13.5 per cent. greater than that of 1914. Labor supply was adequate but not plentiful, with wages remaining about the same. Car shortage hampered shipments for over half the year, resulting in the maintenance of many unfilled orders on the books. Numerous inquiries for spot shipments sent to several producers simultaneously made a further apparent increase in demand. Most of the producers, however, met the demand by increased efficiency and capacity

[1] R. B. Ladoo, U. S. Bureau of Mines, *Eng. Min. Jour.*, Jan. 22, 1921.

output. A few expansions in capacity were noted, but on the whole they were unimportant.[1]

Toward the close of 1920 new plant capacity, building or under consideration, amounted to nearly 300 tons per day, or 90,000 tons per year, The country probably cannot absorb this additional capacity for several years at a normal rate of increase, but new uses which would consume it might be developed through research and publicity. However, it is not likely that much more than a third of this projected plant capacity will actually be built and placed in operation.

Little progress was made in 1920 in the development of new uses which would absorb large quantities of talc, most of the production going into the paper, roofing, paint, rubber, and textile industries. A previously known use, however, as one of the principal ingredients in fire-retardant paints, received an impetus, due to the publication of favorable results of tests on these paints and the licensing of paint companies to manufacture them. This use should create a market for an increasing quantity of talc in the future. The opening of no new talc deposits has been reported, but a few old deposits were reopened.

There was also a large increase in the production of soapstone during 1920, due to the large volume of building construction during the early part of the year. The output figures given by the U. S. Geological Survey show a total of 24,175 short tons, valued at $740,197, an increase over 1919 of 46 per cent. in quantity and 40 per cent. in value. At the close of 1920 the demand was poor.

The following table shows the talc sold and its value and the production and value of soapstone in the United States since 1913. Virginia is the only state now producing soapstone, though some of the earlier years include a small output from California, Rhode Island, North Carolina and Vermont. The states producing talc are shown in the table below.

MARKETED PRODUCTION OF TALC AND SOAPSTONE IN THE UNITED STATES (a)
(In short tons)

Year.	Talc.		Soapstone.	
	Quantity.	Value.	Quantity.	Value.
1913	149,271	$1,280,020	26,562	$628,077
1914	151,088	1,340,874	21,208	524,213
1915	166,336	1,401,197	20,557	490,385
1916	193,909	1,762,842	19,652	490,961
1917	198,613	1,889,672	20,235	.....
1918	192,977	2,104,960	15,530	576,059
1919	168,339	1,822,512	16,504	530,163
1920	198,549	2,311,841	24,175	740,197

(a) U. S. Geol. Surv.

[1] R. B. Ladoo, U. S. Bureau of Mines, *Eng. Min. Jour.*, Feb., 12, 1921.

PRODUCTION OF TALC BY STATES (a)
(In short tons)

	1917.		1918.		1919.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
New York	74,671	$881,462	71,167	$902,100	62,495	$750,765
Vermont	93,960	625,150	90,537	775,012	78,661	665,652
Virginia	6,432	85,856	3,265	24,723	(b)	(b)
North Carolina.	1,275	41,766	1,661	72,348	2,602	76,158
California.....	4,152	74,000	11,864	185,775	9,837	147,470
Georgia.....	3,819	95,314	(b)	(b)	(b)	(b)
Other States (c)	13,404	87,124	14,483	145,002	14,744	182,467
Total.....	198,613	$1,889,672	192,977	$2,104,960	168,339	$1,822,512

(a) U. S. Geol. Surv. (b) Included in "Other States." (c) Maryland, Massachusetts, New Jersey, Pennsylvania, and Washington.

IMPORTS

Imports of talc in 1920 were larger than ever before, according to the U. S. Bureau of Mines. Reports show total imports of 21,729 tons, valued at $442,732, and in addition about 1000 tons of crude talc, with a value of about $8,000. Imports in 1919 were 14,602 tons, valued at $259,004, compared with the previous record tonnage reached in 1916 of 18,882 tons, valued at $230,875. The average declared value of imported talc per ton in 1920 was about $20, as compared with about $17.50 in 1919. The Canadian talc had an average declared value of about $16 per ton, the Italian $35, the French $15, and the British (Indian?) $50. From these figures it appears that the chief competition which domestic producers must meet is that of Canadian talc, much of which is of high grade, suitable for the toilet-powder trade, and which sells for a comparatively low price.

Before the war most of the talc imported into the United States came from France and Italy at an average rate of about 4000 tons per year from each country. The war caused little difference in these imports, except that those from Italy increased to over 7000 tons per year, until 1917, when those from France dropped to about 1500 tons and from Italy to about 4100 tons. In 1918 the imports from France fell to 22 tons and from Italy to 490 tons. In 1919 there was only a slight increase over 1918. In 1920 the indicated imports from France were about 1900 tons and from Italy about 4400 tons. In the absence of definite information, it appears that the talc industry in Italy has recovered to its prewar efficiency, but that of France has only partly recovered.

The new talc mill of the American Mineral Co., at Johnson, Vt., has recently been completed and is now operating in conjunction with the old mill to triple the output of this plant.

IMPORTS INTO THE UNITED STATES OF TALC, GROUND OR PREPARED (POUNDS)
(Fiscal years ending June 30)

Source.	1914.	1915.	1916.	1917.	1918.(a)	1919.(a)	1920.(a)
Austria	1,064,429	807,364	.....	.....	.....	.....	44,092
Belgium	2,500	.....	.....	.....	.....	.....	.....
France	12,138,883	4,845,928	8,586,686	5,599,605	43,132	325,665	3,668,893
Germany	56,345	86,400	.....	.....	.....	.....	3,502
Italy	8,838,858	13,819,223	14,347,386	13,298,942	980,778	1,915,430	9,238,698
England	128,858	57,792	.....	112,492	.....	.....	68,414
Canada	7,296,348	10,789,271	10,443,285	15,073,759	24,370,925	23,704,355	30,245,480
Other countries	10,890	5,189	.....	218,245	.....	.....	189,550
Total	29,537,111	30,411,167	33,377,357	34,303,043	25,394,835	25,945,450	43,458,629

(a) Calendar years.

The American Mineral Co. operates a mill beside the tracks of the Railroad, near Johnson, Lamoille County, Vt. The main source of talc for this mill is a mine about 4 miles distant in the eastern part of the town. A small tonnage, however, is taken from a deposit now nearly exhausted, close to the mill, but this source is utilized only when weather conditions make difficult haulage by wagon from the main deposit. There is a possibility that this deposit may be successfully reopened in the future, for only the talc and not the grit was removed in the early mining and a test pit from the surface beyond the limits of the old workings has encountered good talc.

At the mine has been sunk a new level 50 ft. below the fourth level, or now down to 170 ft. This gives a total mining production of 100 tons daily or 600 tons per week. There is contemplated this year opening up a new shaft about 1000 ft. from the present one with speed-up machinery which will allow raising from 1000 to 1200 tons per week, in addition to the present 600 tons per week.

The old mill has a capacity of 75 tons in 20 hours' running per day. The new mill has a capacity in 10 hours' crushing of 150 tons and in 20 hours' pulverizing 150 tons, giving a total production in both mills of 225 tons, which places this company as one of the largest talc-producing concerns in the world.

There is also under advisement the installation of an aerial tramway direct from mine to mill which will save a great deal of time in bringing the raw materials from the mine to the mill, and allow continuous use throughout the year regardless of road conditions.

Talc in Foreign Countries

Canada.[1]—The talc production of Canada has increased steadily during the last ten years, and as a large part of the Canadian talc is exported to the United States, the increase can be followed approximately

[1] *Eng. Min. Jour.*, Feb. 12, 1921.

from the imports into this country, according to the U. S. Bureau of Mines. Practically all of the talc produced in Canada comes from near Madoc, Hastings County, Ont. The three companies, George H. Gillespie & Co., Ltd., Madoc, Ont., Anglo-American Talc Co., Ltd., Madoc, and the Eldorado Mining & Milling Co., Ltd., Eldorado, are producing ground talc. Of these companies the George H. Gillespie company is probably the largest and ships the highest grade of talc. The mine and mill are efficiently operated and had a prosperous year in 1920. It is reported that the erection of a new mill of larger capacity is under consideration. According to reports of the Ontario Department of Mines, the Eldorado company does not produce a real talc but an altered siliceous magnesian limestone.

South Africa.[1]—The mining of talc in South Africa appears to be a development of the war period, as little appears to have been done in this field prior to 1913. Even then it appears that the early mining was for gold with talc as a by-product. The production for the past few years is as follows in short tons: 1913, 1 ton; 1915, 44 tons; 1916, 132 tons; 1917, 785 tons; 1918, 670 tons; 1919, 757 tons; and 1920, 682 tons. In addition to the above raw talc production the mines themselves have turned out a considerable amount of manufactured talc goods, totaling 412 tons in 1917.

The more important districts in which talc is found are the Barberton district, the Krugersdorf district of the Transvaal, in Zululand, and in Southern Rhodesia. The more important of the above is the Barberton district, though it is said that some very fine foliated talc is found in Southern Rhodesia. The area over which talc is known in the Barberton district is about 10 miles long and averages about a mile in width, and the deposit occurs in the form of nearly vertical bands up to 15 feet in thickness. It is said that the talc reserves in the Barberton district are enormous and if properly developed should yield a large tonnage available for export.

At present there are only about three producing talc mines in the Union. These are the Verdite mine, Jamestown, Barberton, Transvaal; the Scotia talc mines, Joe's Luck, Barberton, Transvaal; and the mines of B. R. Berrett, Greytown, Natal. The first two mines are the principal producers, and operate in the district between Jamestown and the Sheba Valley.

The Verdite mine and the Scotia talc mines each have a plant capable of dealing with 200 tons per month, though it is understood that recently the latter mine has developed its plant capacity to a point where it can turn out as much as 1000 tons per month.

[1] *Comm. Rept.*, July 29, 1920.

PRODUCTION OF TALC AND SOAPSTONE BY COUNTRIES
(In tons of 2000 lb.)

	U. S. (a)	France. (b)	Italy. (c)	Canada. (c)	Spain. (d)	Austria. (c)	Ger. Empire, Bavaria. (d)
1909	130,338	38,433	13,228	4,350	6,154	.....	2,537
1910	150,716	42,316	13,727	7,112	5,143	.....	3,308
1911	143,551	44,092	15,600	7,300	6,226	15,212	3,728
1912	159,270	60,629	15,800	8,270	(e)	(e)	3,551
1913	175,833	(e)	26,456	12,250	(e)	(e)	(e)
1914	172,296	(e)	24,777	10,808	(e)	(e)	(e)
1915	186,891	(e)	24,187	11,885	3,925	(e)	(e)
1916	212,961	(e)	30,294	11,810	1,062	(e)	(e)
1917	218,848	(e)	24,100	15,803	3,803	(e)	(e)
1918	191,477	63,459	19,146	18,190	3,668	.....	.....
1919	184,843	.....	18,942	18,642	3,335	.....	.....

(a) Talc and soapstone. (b) Talc, soapstone and asbestos. (c) Talc. (d) Soapstone. (e) Statistics not available.

Uses of Talc

A recent report by R. B. Ladoo, of the Bureau of Mines, Washington, on the many uses of talc and soapstone, after listing fifty-seven uses, says that considerably more attention has been paid to the technology and utilization of talc in Germany and Austria than in this country, despite the fact that the United States produces 56 per cent. of the world's talc, and Germany and Austria 5.4 per cent.

Talc in Fire-resistant Paint.—In his report of a search for a fire-resistant paint, G. B. Heckel, in *Asbestos*, July, 1920, speaks of one as asbestiform. "Asbestine" forms nearly 60 per cent. of the solid constituents of this paint. As asbestine is magnesium silicate, it is assumed that it is the chrysotile variety of asbestos; but asbestine is a trade name given to a fibrous variety of talc. Practically all talcs are fire-resistant, but some fibrous talc is too bulky for its weight. From the standpoint of the talc industry as a whole, it is to be regretted that trade names should be used, as they cause confusion and lead to mistakes. Talc has so many useful properties and can be utilized in so many different industries that the universal use of its proper name, talc, is strongly urged, from a business as well as a mineralogical standpoint.[1]

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TIN

By Baliol Scott

1920 at least as seen in retrospect leaves the impression behind it of having been one of the most disastrous years in the industry, and that despite the fact that the average price amounted to no less than £296 1. 7., the highest ever recorded with the exception of the quite unrepresentative figures shown during the period of the Tin Control in 1918. While it may seem somewhat difficult to reconcile these two statements, it is necessary to remember that after February, 1920, the course of prices was continuously downwards until the end of the year, that in many cases production had been pushed at the cost of development, and that the mines had little or no benefit from any lower costs of production. An industry does not conform itself to twelve monthly periods, and it became obvious towards the latter part of 1920 that the price was due for a considerably more extended fall in the current year and this added naturally to the preoccupations and difficulties which beset managements in considering their position towards the end of the year. Not only did we see the Cornish industry practically *in extremis*, but the Federated Malay States Government had once more to come to the assistance of the mines and take over production at prices between £250 and £230 per ton until the settlement at the Chinese New Year, and in many other fields similar difficulties had to be faced. In the case of the Dutch Indies similar steps to those adopted in the F. M. S. appear to have been taken at an even earlier period, while other less fortunate districts had to bear the brunt of the storm as best they could.

In a sense tin did but share an experience common to the mining industry generally, but by reason of the excessive inflations which values had received, added to the normally wide fluctuations which the tin market exhibits, the variation from the highest quotation of £421 on Feb. 25th down to £198 on Dec. 23rd was exceptional. This immense slump was the less expected because tin was throughout not a war metal, and it was generally thought that as production has not been stimulated by the war and that it was the Tin Control rather than any inadequacy of the world's supplies that had caused the big prices to be paid for free tin during the war, that we might expect to see a bigger consumptive demand develop with a continuance of high prices. But as "the evil that men do lives after them" so it has been with the Tin Control. It was found that the necessities of the situation had been greatly overesti-

mated, and what has weighed heavily on the market ever since the war has been the large accumulations of tin in the shape of invisible supplies partly carried as consumers' stocks, especially in America but more still as accumulations in producing centers, especially in the East. Even today the situation is far from clear in this respect. What has added to the difficulties of the situation is that the tin industry is not organized in a few powerful controls as is the case with copper, lead or zinc. Production comes mainly from countries with technically undeveloped populations who cannot emigrate or divert their activities to some other channel and whose only resource to meet a great fall is to accept lower wages and do more work, even if it entails an existence below their ordinary subsistence margin. In the economic struggle such as we have witnessed in the last year or so the tin consumer beats the producer every time, and the only consolation that the former is likely to have is the reflection that when he is dead the consumer of future years will deplore his restricted supplies.

MONTHLY AVERAGE PRICES OF TIN IN NEW YORK AND LONDON

Month.	New York.			London.		
	1918. (a)	1919.	1920.	1918.	1919.	1920.
January	84.00	72.50	62.89	293.6 .1	248.9 .11	376.12.9
February	85.00	72.00	60.00	311.12.3	224.3 .4	395.16.6
March	87.00	71.75	61.99	318.15.0	236.18.5	369.14.5
April	90.00	72.26	62.20	329.18.1	225.6 .6	345.13.1
May	105.00	71.94	55.07	364.7 .8	234.9 .5	295.3 .7
June	97.00	71.19½	48.63	321.10.0	238.8 .1	250.18.6
July	98.00	70.39	49.37	359.17.9	253.5 .1	262.1 .6
August	90.00	63.78	47.69	380.16.8	271.8 .0	274.5 .10
September	80.00	55.81	44.62	343.19.1	280.4 .0	270.7 .3
October	80.00	55.62	40.64	335.10.0	279.4 .11	258.8 .8
November	74.00	54.17	37.02	317.7 .7	283.13.7	241.5 .7
December	71.50	55.06	34.15	267.14.3	314.5 .1	212.11.8
Average year	86.80	65.54	50.36	329.11.2	257.9 .8	296.1 .7

New York in cents per pound; London in pounds, shillings and pence per long ton. (a) Approximate only.

World's Production

The present is perhaps a convenient opportunity for examining into the question of production during 1920. The difficulties which have been experienced in arriving at incontrovertible figures in this respect, which have grown steadily since the outbreak of war, increased rather than diminished in judging of last year's figures. The world's statistical service has not yet had any opportunity of recovering and the depression of the industry has not encouraged those engaged in it to divert their attention from the daily question of how to make ends meet to make the necessary special studies in comparative outputs. At the best of times official tin statistics usually take cognizance of exports rather than of

production, and these are apt to be complicated by the liquidation of holdings imported possibly, at any rate in the East, from other fields than those to which the exporting centers are commonly allocated. One or two of these special cases will be noticed in due course. The matter is merely referred to here as suggesting a possible explanation of somewhat extreme differences which are met with as regards production estimates. So far as the writer can judge, however, the following are the figures:

WORLD'S PRODUCTION OF TIN
(In tons of 2240 lb.)

	1915.	1916.	1917.	1918.	1919.	1920.
Malaya	46,766	43,870	39,833	37,370	36,867	34,928
Bolivia	21,794	21,145	27,858	29,280	28,926	29,542(*e*)
Banka	13,773	14,548	13,246	13,247	12,044	13,994
Siam	7,800(*a*)	8,998	8,765(*c*)	9,154(*c*)	8,835(*e*)	9,000(*a*)
Cornwall	4,968	4,697	3,936	4,000(*c*)	3,350(*a*)	2,915
Billiton, etc.	5,750	5,000(*d*)	5,500(*a*)	7,500(*a*)	7,400(*a*)	7,500(*a*)
Nigeria	4,555	5,075	6,510	6,000(*a*)	5,000(*a*)	5,250
China	3,012(*b*)	3,800(*a*)	11,053(*b*)	8,680(*b*)	8'332	8,000(*a*)
Portugal, Spain	.....	250(*a*)	750(*a*)	300(*a*)	300(*a*)	300(*a*)
Australia	2,312(*b*)	5,000(*a*)	4,940	4,747	4,331	4,206
South Africa	2,089	2,003	1,632	1,235	1,003	1,526
India	500(*a*)	900(*a*)	1,200(*a*)	1,000(*a*)	500(*a*)	1,250(*a*)
Total	113,319	115,306	125,223	122,513	116,385	119,211

(*a*) Estimated. (*b*) Shipments to Europe, Asia and United States. (*c*) Siamese official figures for the 12 months to end of March in each year. (*d*) Crude metal exports. (*e*) Reported Pacific Coast shipments.

Estimates of the production of secondary tin in the United States are prepared annually by the Geological Survey. The total figures for 1920 amounted to 23,500 short tons as compared with 24,033 short tons in 1919 and 23,837 short tons in 1918. Of these amounts only 7200 tons was recovered as pure tin in 1920 and 5977 tons in 1919, the remainder representing tin in alloys. Still with a figure something like 30 per cent. of the total of new tin available in the States, the invisible supply from this source is a very material support to consumers in times of high prices.

Production by the United States smelters is a factor of international importance only since the war, and while to a large extent it only represents transference of trade from Germany, yet as it represents a fresh reserve for the American consumer, who is by far the most important factor in the whole situation, it does represent a distinct modification of pre-war conditions.

Stocks

Before finally passing from the question of production during 1920 it is necessary to allude to the accumulation of stocks. It is officially on record that the Government of the Federated Malay States fixed a minimum price at which they would purchase tin concentrates about the

beginning of December, and this was maintained until the Chinese New Year in the second week in February. The exports declared during this period were approximately 7500 tons. As the Government undertook not to sell this material in competition with fresh tin under the price at which they took it over, it is obvious that stocks to this extent continue to be held. The Straits smelters in addition to the produce of the F. M. S. normally buy ores from Siam, Burma, Australia, and Billiton, and have at any rate attempted to do so from Yunnan and Bolivia. Obviously, therefore, they would have accumulations of ore on their own account in addition to the holdings of the F. M. S. Government. The trade returns from the Colony of the Straits Settlements for the fourth quarter of 1920 showed an excess of imports over exports of 8150 tons. If to this be added the imports of concentrates on F. M. S. Government account for January and early February, we get a total of roughly 4600 tons, or a total stock of 12,750 tons at the end of the Chinese year. Market estimates in London ranging between 12,000 and 14,000 tons support this calculation.

It is further admitted by communiqués which have been published regarding co-operation between the F. M. S. Government and the Bank authorities as regards not forcing stocks upon a weak market that the Bank interests also hold stocks. Detailed estimates compiled by the firm of G. A. Witt's Successors put these at the end of the year as 6561 tons. Since that date Banka tin has been steadily produced to the extent of approximately 4300 tons, of which approximately only 1300 tons has been shipped, so that up to the end of April it would appear that the stock had grown to roughly about 10,000 tons. In addition to this we have to allow for the production from Billiton and Singkep, which cannot well be at a lower rate than 7000 tons per year, or say 600 tons per month. Before the war half this quantity went to the Straits smelters and would show in the figures already quoted, but obviously there might easily be up to say 1000 tons of stock at the end of April from this source.

In April and for a considerable time previously it had been reported that about 4000 tons of stock had been carried in Hongkong. Adding these figures together we get a total of stocks held in the East somewhat as follows:

Straits	12,750 tons
Banka	10 000 tons
Billiton	1,000 tons
Hongkong	4,000 tons
Total	27,750 tons

Without wishing to claim too close an accuracy for individual items, it is obvious that a very big stock of tin has been produced above the

capacity of the world to consume it, and these calculations go far to explain why the shipments for the 12 months to the end of last May from the Straits to Europe and America were only 32,321 tons as compared with 58,491 tons for the 12 months to the end of May, 1920. The position from the point of view of accumulation of stocks is emphasized when we consider the large amounts held in warehouse in Great Britain at the present time, and the fact that some American electrolytic tin has been actually sold in England, indicating sufficiently that stocks of American tin exist which cannot be disposed of on the spot.

Consumption

It follows from the premises just discussed that consumption last year fell far short of output, a condition even more emphasized during the present year up to the date of writing at the end of May. It is also shown by the estimates of production that there was very little falling-off during 1920 in that department. Beyond this it is practically impossible to carry the question statistically. The uses of tin are well known and are conditioned mainly by the activity in the steel and engineering trades. The production of steel last year was perhaps not much more than half the world's total in 1913 and today it has been much further reduced. Under these circumstances it must be obvious that for the time being consumption is greatly impaired and stocks in the writer's opinion are larger than is generally realized.

IMPORTS OF TIN INTO THE UNITED STATES

Year.	Pounds.	Value.	Year.	Pounds.	Value.	Year.	Pounds.	Value.
1906..	101,027,188	$37,446,508	1911.	106,936,872	$43,390,639	1916.	149,237,760	$55,840,205
1907..	82,548,838	32,075,091	1912.	116,003,385	50,371,102	1917.	154,470,040	68,372,034
1908..	82,503,190	23,932,560	1913.	104,282,230	46,900,314	1918.	164,579,905	104,588,619
1909..	95,350,020	27,559,937	1914.	95,049,612	32,861,188	1919.	112,741,207	62,761,967
1910..	105,137,740	33,921,449	1915.	115,636,332	38,736,909	1920.	163,064,231	92,581,927

The Industry in the Various Countries

North America.—The United States remains as far as ever from discoveries of tin of any importance within its own territory. The impulse given to prospecting by the war has died away without adding to our knowledge of any workable deposits and even the small production which is obtained from Alaska seems to diminish rather than increase. In 1920 the output amounted to 20 tons, compared with 40 tons in 1919. Some work was done during the year in New Mexico round the headquarters of the Gila river on the borders of Socorro and Sierra counties. The district was reported on by J. M. Hill of the U. S. Geological Survey,

but his opinion was that the district did not look promising as a possible producer of tin. Some interest was also taken by United States capital in investigating the possibilities of Mexico. Mexico has produced a little tin almost from prehistoric times, deposits existing in the State of Aguas Calientes in Zacatecas and on the borders of Durango, and they have been examined from time to time by technical engineers. No serious production has, however, been obtained and the general tenor of their reports has been that there is insufficient concentration to give any of these deposits serious value for enterprise on a modern scale, and naturally with the immense fall which has taken place in the value of the metal interest has again lapsed.

But if tin mining makes no progress, tin reduction has developed rapidly. Quite apart from the secondary tin industry, which is an important one, there is now a large production of American smelted metal. Early in the year the output in 1920 was reported as 14,513 tons. Of this the Williams Harvey Corporation are estimated to have produced about 7000 tons, which if the total figure be correct gives the American Smelting & Refining Corporation a lower output than they are usually credited with. This enterprise is believed to be dependent entirely on its Bolivian supplies and when in the early part of this year a shipment of some 620 tons was received in England the analyses were awaited with considerable interest. These disclosed a very pure metal which, however, does not appear to have been more readily salable in this country than in the States. Some Continental buyers, however, are reported to have been very appreciative. The history of both copper and nickel evidences long existing trade prejudice against electrolytic metal, and it is frequently objected that electrolytic tin lacks certain physical qualities which consumers demand and that its market, therefore, is more limited than that for tin refined by the old methods. Whether this is more than trade prejudice it is impossible to decide.

There has been a considerable amount of discussion as to the imposition of a tariff on the imports of tin and tin ore in the United States. The tariff discussions on the subject have, however, been mystifying rather than informing and the general impression seems to be that a duty will not eventuate.

Malaya.—The official figures of export, subject to revision, for 1920 were 34,928 tons, which compare with 36,935 tons in 1919 and 37,370 tons in 1918, a decline for last year of 2007 tons. Considering that the average London price was about £40 per ton better and that towards the end of the year the Government guaranteed prices between $115 and $120 per picul, this decrease in the export of 5.4 per cent. is noteworthy. The President of the Chamber of Mines in reviewing the year's working attri-

buted the decline not merely to the slump in prices, but partly to the inevitable high cost of production accentuated in the case of Malaya by the rice famine, and also to the fact that the huge prices for tin in the earlier part of the year had resulted in a great deal of unrest among the coolies, who preferred in many cases to go and prospect on their own account, so that in many cases it was found impossible to maintain the proper labor complement. These two latter conditions showed a tendency to adjust themselves towards the end of the year, and though it is admittedly extremely difficult to give any representative figure for the whole industry the President estimated that the high-water mark of cost which amounted to about $135 in the middle of 1920 had fallen to somewhere about $120 per picul by the end of the year. In pre-war days the dollar per picul price when doubled represented the £1 per ton price closely. War conditions altered this ratio owing to the greatly increased freight, insurance and delays in handling, and at times the large premium on Straits has made it a less accurate measure of the London price, which is usually quoted in terms of Standard. Under current conditions, however, the old parity is returning and for the purposes of rough comparison it is used here; $120 thus represents about £240 per ton, so that it is obvious that at the end of the year production generally was considerably above London price. As a result every effort is now being made to reduce production costs and exports for the current year will be watched closely to see what success this effort to scale down costs will achieve. At the time of writing the exports are less severely affected than might have been expected, amounting as they did for the first four months to 11,291 tons as compared with 12,655 tons for the same period of 1920. Despite this, the situation has created great anxiety in Malaya and negotiations have been opened with producers in the Dutch Indies and Siam with a view to coming to some arrangement to stabilize prices in the future. The desirability of such a step is much more self-evident than its practicability, and in his review of the industry the President of the Chamber of Mines describes the outlook as more depressing than perhaps the Chamber had ever been called upon to face. In connection with the question of working costs it is necessary to discount figures given for individual dredging properties often quoted as indicating that there is even at current prices a considerable margin of profit. In the first place the dredging industry represents but a very small proportion of the output. Roughly speaking the Chinese-owned properties represent 70 per cent. of the output, and of the remaining 30 per cent. of foreign-owned enterprises, probably quite half is produced by other than dredging plants. Nor is it possible to say whether the figures given are anything more than working costs. Unless the life of the pro-

perties and the capital cost of the enterprises are allowed for, actual working costs in a given year are a very incomplete basis of estimation.

The Government Report on mining in the F.M.S. during last year contributes little beyond what we already know from the report of the Chamber of Mines. Probably the Department is still feeling the effects of the war, as not only is the report retarded but lacks the detailed information customary in pre-war times. For years past correspondents in the Federated Malay States have referred to a certain decline in the output at a comparatively early date, and it is important to note that since 1913 every year has shown a decrease, in most cases well marked, in the exports, and last year's shipments were the lowest since 1891. Curiously enough last year's decline was not universal as has been the case fairly regularly since it began, as the State of Perak actually showed a very slight improvement.

PRODUCTION OF TIN BY STATES (a)
(In piculs of 133⅓ lb.)

	1911.	1912.	1913.	1914.	1915.	1916.	1917.	1918.	1919.	1920.
Perak.....	437,339	477,240	493,753	479,621	466,634	457,660	414,000	387,750	371,722	371,848
Selangor.....	231,175	255,382	252,765	244,665	234,155	205,650	184,135	170,359	178,608	148,715
Negri Sembilan.	29,230	29,071	36,821	35,900	20,900	15,240	12,328	16,246	14,761	11,710
Pahang.....	43,954	51,779	58,791	63,723	63,980	54,464	58,734	53,460	55,427	54,632
Total.....	741,698	813,472	842,130	823,909	785,670	737,014	669,197	627,815	620,518	586,905

(a) Exports of tin ore, the latter being calculated to its assumed metal contents, upon which duty is paid to the F. M. S. Government.

The contrast between Perak and the other three States is so marked as to invite some explanation, but the report does not vouchsafe any. We believe that it will be found, however, in the development which is taking place in the employment of machinery, more especially dredges. The labor force at work in the Protectorate numbered in all 89,557, as compared with 113,107 in 1919 and 144,621 in 1918, and considerably over 200,000 before the war. In Perak the total was 50,622 at the end of the year, as compared with 64,760 in December, 1919, so that if these figures for the end of the year are representative of the year as a whole they indicate the effective employment of machinery to a greatly increased extent.

In the case of other States the differences are far slighter. These figures justify the conclusion that in the more progressive mining States there is a marked transference from hand to machine power as the basis of successful operation, and this is a factor which manufacturers of power plant will do well to observe, as obviously the transition period long expected is now taking place. In particular, they may note with interest that while there were 20 dredges operating last year, no less than 32 are proposed or under construction.

The Yukon gold-dredging company was busy prospecting tin-dredging areas in Malaya during the year, but though the extent and thoroughness of their operations led to various reports of decisions to operate on a big scale, it seems uncertain as yet whether they have taken any final decisions.

South Africa.—The Transvaal mines, which had the benefit of Government contract towards the end of the war-period assisted by the high prices prevailing during most of the year, made an improved showing so far as output is concerned. The production amounted to 1526 tons as compared with 1003 tons in the year previous. It cannot be said, however, that they improved their position and by the end of the year they all appear to have been losing money. In a recent report on the Zaaiplaats company, the directors stated that all hope of carrying on the mine profitably under present working conditions when tin was below £200 per ton was at an end. The Stavoren property was closed down in November and the Lieupoort tin early in the current year suspended crushing in view of production at a loss. The Rooiberg also closed down last year, and generally speaking the Transvaal tin mines with their recognized unstable orebodies did not improve their position during the year.

Belgian Congo.—The Belgian companies are prosecuting their efforts to develop their tin resources, the character of which has been discussed in earlier volumes of THE MINERAL INDUSTRY. The Geomine, Ltd., is said to be producing alluvial tin at several points in its concession, with a present output of about 300 tons of concentrates per year. Current production is, however, being stacked. Shipment of Congo ores to the United Kingdom has proceeded irregularly. Small parcels of Congo ores have been received by English smelters during the year, amounting to about 200 tons in all.

At a meeting of the Union Miniere the Chairman stated that 340 tons of concentrates were won from the Busanga mine last year. This would be probably additional to those workings already mentioned. The Chairman further stated that the Busanga output had substantially increased recently and was now over 50 tons per month, and that another mining center was being opened with an assumed capacity of 25 tons per month. Prospecting work is stated to be proceeding vigorously and at the end of last year 5000 tons of payable concentrates had been proved.

Southwest Africa.—Occurrences of cassiterite in German Southwest Africa were known previous to the war, and during the past year a certain amount of prospecting appears to have been done under the restrictive conditions existing, but it is too early as yet to say whether these will yield results of value.

Siam.—The writer has been unable to gather any relevant figures relating to tin mining in Siam beyond those contained in last year's issue of THE MINERAL INDUSTRY. No official figures of output are available since the year ended Mar. 31, 1919, when the output amounted to 8835 tons, of which just over one-third (52,124 piculs) was won by dredging and the balance (96,301 piculs) by other work. The great bulk of the production is from the district of Puket (124,399 piculs), the balance being from Patani (8560 piculs), Nakoru Sitamarat (12,846 piculs), and Surat (2020 piculs). Progress in dredging has, of course, been hampered by the difficulty of obtaining machinery and spares generally, while as regards hand-work conditions resemble very closely those on the Malayan side of the boundary to which commercially Siamese tin mining belongs. We may, therefore, fairly assume that the output has conformed generally to experience in Malaya itself and shown but little variation on the earlier year, the more so as the Siamese output has been between 8500 and 9000 tons in the four previous years. For regulative purposes the output is assumed at 9000 tons.

China.—There is no reliable information available with regard to the mining industry in China for last year, in fact apart from the annual report of the Chinese Maritime Customs Commissioner, the writer is not aware of the existence of any source of information from Yunnan itself, and this report is never available for at least a year after the period covered. Statements have been published in London to the effect that the Chinese production last year increased considerably, but this is unlikely for several reasons. The Chinese Maritime Customs Report[1] written at the end of March, 1920, stated that the industry had been suffering for some time in a great variety of ways. Throughout most of 1919 tin stocks accumulated and could not be exported, and when towards the end of the year export was possible the tin was merely transferred to Hongkong, where much of it was already mortgaged. Quite apart from local troubles such as rice famine, an unparalleled increase in brigandage, shortage of currency and widespread unemployment, probably the most serious factor which the industry had to face was the high price of silver, which had the effect in the year when sterling prices rose steadily of reducing the local dollar price considerably below the level to which tin fell after the armistice. During 1919 tin declined from $70 to as low as $58 and at the end of the year had only recovered to $80, as compared with prices nearly double that in 1918. The subsequent gradual fall in the price of silver has, of course, assisted the mines as compared with the decline in tin prices, and during the spring of the current year the writer understands that a considerable amount of the remaining stocks

[1] *Min. Jour.*, Apr. 30, 1921, p. 332.

of tin in Hongkong have been sold, the amount remaining being probably not more than 2000 tons. Under the circumstances of manifold difficulty, however, existing during the earlier part of 1920, and the improbability of their being suddenly relieved, it seems difficult to imagine that an old industry which has of late years given a very uniform output of from 7500 to 8000 tons can suddenly have largely increased, and for that reason the writer assumes the output to have been about the level of recent years. Exports during 1920 were 11,305 long tons; in 1919 they were 8200 tons and in 1918, 8682 tons. According to the Chinese Commissioner of Customs, the Straits Trading Co. again made strenuous efforts to obtain a hold on production, entering into 180 contracts for a supply of some 10,000 tons of concentrates for their overdeveloped Singapore smelter. Once again, however, local interests appear to have proved too strong and the company has been forced to go further afield, even to Bolivia in search of material.

Great Britain (*Cornwall*).—The year 1920 proved the most disastrous that Cornish mining has ever experienced. This was foreshadowed in last year's article when it was pointed out that in the opinion of the Committee of the Board of Trade profits were unlikely to be made by the mines with tin under £400 per ton. When the Government refused State aid to tide the industry over a critical period it was only a question of time when the mines would all have to shut down. While the end was obvious in most cases by Christmas time, a few of the properties held on into the current year, but by the middle of February practically all work was stopped. Troubles do not come singly and in addition to the immense depreciation in the price of tin the bottom fell out of the wolfram market, and arsenic, though commanding a high price, has been in small demand and the values are low as compared with the period of the war. To crown these troubles the mines saw little prospects of cheaper coal, and when foreign coal prices broke the coal strike followed. Under all circumstances the production for the year was higher than might have been anticipated, but this was due in part no doubt to the mines working ore wherever they could obtain it, as it was a question from week to week whether they could manage to stagger on. The total production from mines and quarries was 4858 tons of concentrates, equivalent roughly to 2915 tons as compared with 3350 tons in the previous year.

Any prognostication as to the future is very difficult. The Cornish mines are for the most part deep and heavily watered, and it is the pumping charges so tremendously increased by the huge price of coal and transport that has been largely responsible for their going under. Obviously if a mine cannot afford pumping charges when it is working, still less is it possible to do so when it has shut down. Sanguine statements

as to resumption are common enough when a mine closes down, but when it is full of water and it is a question of pumping out the whole of some of the enormous workings which exist in Cornwall the proposition presents itself in a different light. Of course, so long as the tin market remains weak there can be no question of reopening and it will be time enough to discuss prospects of resumption when the commodity shows signs of a permanent improvement.

Nigeria.—Even less information than usual is vouchsafed to us with regard to tin mining in Nigeria during last year. There are no official statistics and publicity is not regarded as an essential to success by the tin industry generally. As far as the writer is aware the whole of the Nigerian concentrates are still sold to the English smelters, Williams Harvey & Co. being chiefly interested. Under these circumstances the arrivals of tin ore into this country are the best basis upon which to estimate production, but at times like those in which we have been living of late exports and production figures are not necessarily the same thing, and it is possible that the high prices which ruled in the early part of the year resulted in some accumulations of tin being moved, but this is mere supposition as the writer has no information to confirm the surmise. The most that can be said is that the import of Nigerian ores into Great Britain during last year amounted to 7507 tons, which is higher than the somewhat unfavorable reports of conditions out there would suggest. Reckoning the imports at 70 per cent., we get a total of 5250 tons of metal as the production for the year, which appears to be slightly above that of 1919. Last year considerable reduction was anticipated and similar expectation is entertained of this year, possibly with greater probability. Reports of labor are unsatisfactory and some of the mines have been forced by the low price of tin to restrict their output, and among the weaker properties even to close altogether. The royalty on tin has been temporarily modified and there is a natural disinclination in the case of these alluvial properties with short life to go on exhausting their reserves when the operations mean a loss or at best a very small profit.

Bolivia.—At the date of writing reliable information as to the progress of the tin industry in Bolivia last year is extremely difficult to collect. The only official figures as to production known to the writer are the statistics of tin passing the frontier Customs Houses upon which the export duty is levied. These are available so far only for 1919, the 1920 figures not having yet been received in London. This delay is attributed primarily to the revolution and consequent disturbance of the regular routine of official life, and partly also perhaps to a censorship

more or less strict which seems to have existed at some fairly recent periods. The result is that we are thrown back on private advices as to shipments from Pacific ports of barrilla. Were the industry proceeding on a perfectly regular course, such figures might be a satisfactory substitute. However, with the conditions which have existed along the South American coast during the past year it is difficult to judge how closely any month's shipments correspond to producing conditions at the same time. Unknown delays may supervene between the production at the mines and the passing of the tin through the Bolivian Customs, and subsequently to that by congestion at the Coast ports, so that Customs figures and Coast-shipment figures for the 12 months of 1920 may really represent a considerable difference in date of original production, so that where the industry experiences rapid alternations of fortune Coast-shipment figures may fail to give a correct idea of the situation at any particular date. Thus in 1919 the official figures of export through the Custom Houses, including tin bars, was 29,100 metric tons, while the Pacific Coast shipments for the same period were returned at 27,389 tons. Pacific Coast shipments in 1920 are returned by Messrs. Witt's successors at 29,542 tons. On the other hand the writer's information is that the heavy fall in the price of tin towards the end of the year coupled with other difficulties resulted in a close-down or partial close-down of nearly all the properties. The probability, therefore, is that instead of the current production being larger than the exports, as was the case in 1919, the production contracted and the Coast shipments originating in an earlier period benefitted by the larger production which the rising prices of the latter part of 1919 made possible—in short that the position of the earlier year was reversed in 1920. This conclusion is supported in some degree by the lower figures of arrivals from Bolivia in the United Kingdom recently, for the writer has no information to suggest that the United States is largely increasing its takings of Bolivian ore. The newly created British Imperial Mineral Resources Bureau has gone on record with two widely different figures for Bolivia during last year. While adopting the above quoted estimate for Pacific Coast shipments of 29,542 tons, it states the output of tin as 17,725 tons. These figures are merely issued in tabular form and no explanation is obtainable as to their foundation. For that reason they are mentioned with all reserve. As up to the present time there have been no official figures of production in Bolivia but only of export, the production total obviously stands in need of further explanation. Should the figure prove to be correct it would emphasize the difference which the writer suggests may exist between figures of export and figures of shipment.

EXPORTATION OF TIN ORE FROM BOLIVIA
(In metric tons)

Year.	*Barrilla.* Tons.	Tin Contents. (a)	Year.	*Barrilla.* Tons.	Tin Contents. (a)	Year.	*Barrilla.* Tons.	Tin Contents. (a)
1904..	20,369	12,221	1910.	38,548	23,129	1916...	35,097	21,145
1905..	27,690	16,614	1911.	37,073	22,434	1917...	46,420	27,858
1906..	29,370	17,624	1912.	38,378	23,027	1918...	48,801	29,281
1907..	27,678	16,607	1913.	44,594	26,756	1919...	45,648	27,389
1908..	29,938	17,963	1914.	37,259	22,355	1920...	49,237	29,542
1909..	35,566	21,340	1915.	36,324	21,794			

(a) Tin content of the barrilla (black tin concentrate), computing the latter at 60 per cent. metallic tin.

Since the New Year, though the price of tin has fallen somewhat, the miner has been assisted by the decline in exchange and there has been a fairly general resumption of work, though apparently on a diminished scale, and largely probably because Government revenue at the present time is derived largely from export and import duties, and because the miners apart from their own farming operations have no other source of livelihood.

The year 1920 was notable for a more definite entry of American interests into the Bolivian tin industry. Early in the spring the Guggenheim interests purchased a comparatively unknown tin deposit called the Empresa Minera Caracoles, for which they are said to have paid $5,000,000 in gold. These concessions are numerous and altogether comprise a large block of ground, though no producers of any previous importance were included. Elsewhere their engineers sampled several well-known properties, among them those of Messrs. Soux of Potosi, and were reported to have examined also some of the Aramayo properties. They also took an option on Morococala, which they rejected as too small, though it was producing about 150 tons of concentrates per month. They also established a central camp and imported an amount of machinery and stores into the country suggestive of an intention to operate on a very large scale in the tin industry.

What effect the gradual crumbling of the tin market and the revelation that for the time being supplies are much in excess of requirements may have had upon these projects the writer has no means of knowing. Reports have been current in American trade circles from time to time that the American Smelting & Refining Co. were finding considerable difficulty in getting rid of their electrolytic tin, and though there are excellent reports from German sources of the purity of some of the metal which was shipped out of the States to be realized in London, many consumers maintain that it lacks certain physical characteristics which they desire.

The big Arica smelter designed for an eventual capacity of 12,000 tons of tin is reported to have been an entire failure commercially and to have been definitely abandoned.

The writer has pointed out on earlier occasions that the growth of the smelting capacity of the world was bound to lead to increased competition for ore. This was illustrated by the fact that the Straits Trading Co. were at one time actually buying ore in Bolivia which they shipped to Singapore via San Francisco. The same consideration may well have been present to the minds of the Guggenheim directors with their big smelter in New Jersey. At any rate they do not appear to have had imitators among other American groups.

It is very difficult to judge of the outlook before Bolivia at the present moment, for while there is practically no certain information to be obtained of any general character, there is a constant circulation of stories, generally of a highly improbable character, and which events generally prove to be untrue. Such stories formed quite a feature for market speculation during last year. So far as the writer can learn the country appears to be experiencing its share of labor unsettlement, in close imitation of labor programs in Europe.

Australia.—Complete figures of Australian output have been compiled by the Australian Metal Exchange and are shown in the table.

AUSTRALIAN TIN OUTPUT
(In long tons)

	1917.	1918.	1919.	1920.
New South Wales	1,781	1,698	1,776	1,600
Queensland	824	917	596	981
Victoria	93	88	74	60
Western Australia	266	270	207	165
Tasmania	1,846	1,579	1,580	1,310
Northern Territory	130	195	98	90
Total	4,940	4,747	4,331	4,206

The Queensland output was 1486 tons of concentrates as compared with 994 tons in the previous year, equivalent to 981 tons of metal compared with 596 tons. On the other hand Tasmania declined from 1580 tons of metal to 1310 tons, a shortage of 270 tons. Tin mining in Australia is of very long standing and the industry is in decay. With the exception of the Ardlethan tin field in New South Wales there is no producing area of any recent origin, and it is known that the slump in tin at the end of last year and still more in the present one placed most producers in a position of great difficulty. In Queensland the industry only carried on by reason of the State taking over the Irvinebank tin smelters and it would not be at all surprising if the fate which overtook Cornish mines in the

early part of the current year were largely reflected in Australia also. Dependent as it is entirely upon highly paid white labor, and without capital to utilize times of depression to develop ore reserves.

Dutch East Indies.—Tin mining in the Dutch East Indies is more centralized than in any other part of the world. The bulk of the production in the island of Banka is carried on by the Administration itself, while the two private concerns, Billiton and Singkep, are Government concessionaires. Under these circumstances there is more possibility of a systematic policy being pursued than by producers in other parts of the world. In pre-war days there was a general practice to ease off production when the market was unfavorable and to extend output when prices warranted it. The concerns are large and prosperous and were not driven by lack of capital to produce in bad times in order to keep their heads above water. The same practice probably still prevails. The Banka output last year at 13,994 tons showed a gain of 1950 tons, and up to the end of April last the figures for this year were very little short of the 1920 output. These are, of course, smelting figures representing perhaps somewhat earlier production from the mining point of view. Shipments on the other hand were below the figures of output and amounted approximately to 11,600 tons. Here as in the case of the Federated Malay States the existence of stocks is admitted in the statements that have been made of an agreement to keep them off the market for at any rate the earlier part of this year. According to the estimate of Messrs. G. A. Witt's Successors the stock in the East at the end of the year was approximately 6500 tons, and with the subsequent figures of production and shipment up to the end of April of the current year this figure has advanced to between 9000 and 10,000 tons.

With regard to Billiton, no particulars are available to the writer. As a result apparently of the development program to which the company devoted its attention previous to the war, the output which had been declining for some years has towards the end of the war-period shown considerable advance. Thus the output for the year ended June 1, 1914, was 4614 tons, and this increased yearly until in the period ended June 1, 1918, it reached the figure of 6945 tons. The probabilities are, therefore, taking into the consideration the increase in Banka output, that last year's figure must have been in the neighborhood of 7000 tons. What, if any, stock has been accumulated, of course, it is impossible to judge. Rather more than half the output appears to go to Singapore and would therefore figure in Straits statistics, but between 2000 and 3000 tons appears to be reduced and refined locally.

According to a statement in the *Engineering and Mining Journal* of Dec. 4, 1920, the Billiton output was considerably larger than indicated.

These figures are said to be compiled from the *Jaarboek van Het Mijnwesen in Nederlandsch Oost-Indie* and put the 1918 output at 11,555 metric tons of tin and 5253 tons of concentrates. These figures are, however, much in excess of the company's own statement for that year noted just above.

There is also a small production from the Singkep Co., which in pre-war days was about 500 tons. Altogether, therefore, the estimate for the Dutch Indies is in round figures:

Banka	14,000 tons
Billiton	7,000 tons
Singkep	500 tons
Total	21,500 tons

India.—As pointed out in last year's MINERAL INDUSTRY, it is impossible to obtain accurate figures of the production of tin from India. The bulk of the output is from Tavoy and is in the form of mixed tin and wolfram concentrates. The Tavoy Chamber of Mines estimates[1] the production of mixed concentrates last year at 2800 tons. There is no means of settling the proportion between the two minerals, and during last year owing to the decay of the wolfram industry and the efforts made to mine tin ores in preference to wolfram, it was additionally difficult to arrive at any settled figure. For the sake of reaching some figure for the purposes of general statistics, the writer has adopted the rough expedient of assuming that half the amount represented tin concentrates. In addition there is some production from Mergui and the districts to the north of the Malay Peninsula, as well as from outlying producers in Burma like the Southern Shan States. The Indian Geological Survey's figure for 1919 was 1350 tons of concentrate and 137 tons of metal, equivalent as nearly as possible to 1000 tons of metal. Under the influence of higher prices and a collapse in the wolfram market the production last year should be somewhat higher than this. On the basis of the estimate taken for the Tavoy field during 1920 and the production in the other centers enumerated but of which we have no record as yet, the production would probably be between 1000 and 1500 tons for India, say 1250 tons as an estimate.

METALLURGY

There is little or nothing to record as regards the metallurgy of tin. The interest which was taken in research work in Cornwall, stimulated by the experimental successes obtained with flotation work, gradually

[1] *Min. Jour.*, Feb. 26, 1921, p. 104.

gave place to the more urgent consideration as to how to keep alive the industry in the face of the desperate conditions with which it was confronted. In view, too, of the dominant position occupied by the Minerals Separation Co. in this field of research, there was a disinclination to pursue extensive investigations with the possibility that any process developed might ultimately be found to infringe upon patents held by that company, and now that the Cornish industry is at least temporarily dead, nothing has been heard for a long time of further experiment, still less of the adoption of flotation methods.

Experiment in the reduction of tin ores and refractory residues by means of chlorine has made progress and a company has been formed which the writer understands has erected a demonstration plant which will include the recovery of tin from tin ores, the purification of impure tin and the manufacture of tin salts. So far, however, operations have not reached a point at which those interested are in a position to give particulars for publication.

TITANIUM AND ZIRCONIUM

TITANIUM

Titanium occurs commercially in nature in the form of the mineral rutile (titanium oxide, TiO_2) and the mineral ilmenite (titanium iron oxide, $TiFeO_3$). These minerals are produced in the United States by the American Rutile Co. from their mine at Roseland, Nelson County, Va., and by Buckman & Pritchard, Inc., from the beach sands at Pablo Beach, Fla. The minerals are recovered by concentration. In 1918 the total production was 261 short tons of rutile concentrates (95 per cent.) and 1644 short tons of ilmenite concentrates (53 to 55 per cent. TiO_2), of a combined value of $57,750. In 1919 the production of the American Rutile Co. in Virginia was 102 tons of rutile concentrates and 106 tons of ilmenite (48 to 50 per cent. TiO_2), of a total value of $22,520. In 1920 the Virginia production amounted to 277 tons of rutile concentrates and 268 tons of ilmenite. There was no production from Florida in 1920 and the output there in 1919 is not available for publication.[1]

Rutile is also produced in considerable quantity from deposits in southern Norway, the largest being in Sogndal, south of Rgersund, at Raagefjord, and Jössingfjord. Deposits of ilmenite are more numerous, occurring in Scandinavia, Russia, Australia and Africa, but there has been little commercial production. In addition there are large and important deposits of titaniferous iron ores, but titanium minerals are not recoverable from these. In smelting the titanium is partly reduced and passes into the pig iron, the presence of titanium making the smelting difficult.

The principal use of titanium has been as a scavenger in steel making, and the demand from this source is still a large one. For titanium-treated rails, however, the demand has been declining until at present the production of such rails is almost negligible.[2]

An interesting use for titanium was found during the war, that of producing smoke screens, the compound titanium tetrachloride ($TiCl_4$) forming a dense white smoke by hydrolysis when exposed to the air. Little was used for this purpose, however, on account of the difficulty of obtaining a large supply in the short space of time which was available.

During the past 5 years the use of titanium for pigments has developed rapidly, and this is likely to prove the most important use in the future. Titanium-white, pure TiO_2, appears especially promising. It is non-poisonous and has a very large covering capacity. It is used princi-

[1] U. S. Geol. Surv.
[2] See table on page 366.

pally by mixing with various amounts of barium sulphate, making a product of the nature of lithopone. BXX Titanox, made by the Titanium Pigment Co., Niagara Falls, N. Y., has the same specific gravity as lithopone of a well-known brand (4.28); it contains 25 per cent. TiO_2 and 75 per cent. $BaSO_4$.[1]

The price of ilmenite during the year ranged from $8 to $20 per ton. This was for concentrates carrying a minimum of 45 per cent. TiO_2. Imported rutile was quoted during the first half of the year at 15 to 16 cts. per lb. in carload lots, and during the last half at 12 to 13 cts. per lb. in carload lots.[2]

In the steel industry titanium is used in the form of ferrotitanium and ferro-carbon-titanium. It is reported that certain noteworthy developments have been made in the case of complex titanium-bearing steels for armor plate and ordnance, but detailed data are not available. If titanium should prove to be a valuable alloying element for use in steel, there will be no possibility of shortage, since the known deposits of titanium minerals are sufficient to supply any discernible demand for a long time to come. Ferro-carbon-titanium sold during 1920 at $200 to $250 per ton, and alumino-thermic ferrotitanium was higher.[3]

Manufacture of Titanium-white.—Following is a description[4] of the process used by the Titan Co. of Fredrikstad, Norway, in preparing titanium-white. The ore used is from the Blaafjeldet and Storgagen deposits at Raagefjord and Jössingfjord, and carries 25 to 45 per cent. TiO_2.

The ore is sorted, pulverized, classified and washed over washing boards. The dressed ore is then carried 7 kilometers by rail to Raagefjord and from there shipped to Fredrikstad. After being dried and finely ground the ore is thoroughly mixed with sulphuric acid in a special mixing apparatus, and the mixture is then transferred to a decomposition plant, where the reaction between the acid and the ore is started by gas heating. The apparatus works continuously and delivers the decomposed titanium ore and sulphuric acid mass in the shape of cakes, in suitable sizes, which are crushed and ground and then dissolved in water. The titanium and iron solution obtained in this way contains particles of non-decomposed minerals. It is necessary to separate these particles from the solution. Filtration has been tried in every possible way, but the problem could not be solved in a practical manner. In the present process the undecomposed mineral is separated by settling in large vessels. Certain devices are used by which the speed of the settling is greatly accelerated. The quite clear solution is then electrolytically reduced, whereby the ferric iron is converted into ferrous iron. On boiling in a vessel provided with internal steam coils the titanium dioxide falls out as a white amorphous powder.

The elimination of ferrous sulphate and free sulphuric acid from this powder constituted one of the most difficult technical problems. It was impossible to find

[1] *Chem. Met. Eng.*, Oct. 27, 1920.
[2] *Eng. Min. Jour.*, Jan. 22, 1921.
[3] *Iron Age*, Jan. 6, 1921.
[4] *Chem. Trade Jour. and Chem. Eng.*, Sept. 25, 1920; abstract, *Chem. Met. Eng.*, Oct. 27, 1920.

a suitable filter, both on account of the extreme fineness of the titanium oxide particles, and on account of the corroding effect of the acid solution A washing system was eventually adopted, in which practically all the iron is removed. Traces of sulphuric acid are eliminated by the addition of barium carbonate, and so the final product contains a certain amount of barium sulphate. Very minute traces of iron—0.02 per cent.—are sufficient to discolor the product, and the details of how the last small traces of iron are removed are not divulged, although it is suggested that it is effected by adding substances which form colorless compounds with iron. The product is calcined, ground to such a fineness that 99.95 per cent. passes through a mesh of 5000 to the sq. cm. The pigment is then mixed with linseed oil and a little zinc-white is added. After thorough incorporation in the edge-runner mill, the product is ready for use.

As compared with white lead and zinc oxide, the advantages titanium-white offer are said to be considerable. It possesses a greater covering power than either, is non-poisonous and is chemically inert. Unlike zinc oxide, it exerts no saponifying action upon the linseed oil. Its low specific gravity renders it very easy to apply.

Zirconium

An increased demand for zirconium ore (zirkite) was noted during 1920. This product, which is the natural oxide of zirconium imported from Brazil, is now recognized as one of the so-called super-refactories for high-temperature work. Ferrozirconium is still in an experimental stage. Alloys containing from 25 to 35 per cent. zirconium metal were produced during the war, but carried an objectionably high percentage of silicon and aluminium. Recent improvements in the metallurgy of zirconium have resulted in a lowering of the price of zirconium metal powder, which closely resembles tungsten powder in appearance. It is expected that zirconium metal powder will be produced on a semi-commercial scale and sold at a price of about $12 per lb. for a product running over 95 per cent pure.[1]

A 20-per cent. ferrozirconium has been used in England to some extent instead of ferrotitanium. The effect of ferrozirconium upon cast iron has recently been investigated by Moldenke, who states that it is useful here as a deoxidizer and that an addition of 0.10 per cent. causes increased strength and deflection. Some complex alloys high in zirconium for use as cutting tools have been developed by Cooper (U. S. Patent 1,350,359).[2]

The price of zirkite during the first half of 1920 ranged from 4½ to 7 cts. per lb. in carload lots. Dead-burnt zirkite in grain or powdered form sold at 8 to 11 cts. per lb. Zirkite bricks in standard shapes sold at 65 to 90 cts. each in carload lots. The last half of 1920 witnessed a drop in prices, zirkite selling at 3½ to 4 cts. per lb., dead-burnt at 6 to 8½ cts. per lb., and bricks at 60 to 85 cts. each. The pure oxide sold during the first half at $1.10 to $1.20 per lb. During the last half, the

[1] H. C. Meyer, *Eng. Min. Jour.*, Jan. 22, 1921.
[2] *Iron Age*, Jan. 6, 1921.

price dropped to 75 cts. to $1 per lb., owing to cheaper methods of production.

Zirconia Refractory Cement.—In a paper read by Mark Sheppard before the American Ceramic Society it was stated that crude zirconia with high shrinkage and impurities could not be bonded with clay to make a satisfactory cement. When a part of the crude zirconia, however, was partly replaced by pure zirconia, the purified material having lower shrinkage, a cement could be formed. When this was applied as a wet wash to a bung on certain furnaces, an increase of 25 per cent. was secured in the number of heats run before replacement.

TUNGSTEN

By Colin G. Fink

The tungsten industry of the United States during 1920 was practically non-existent. Most of the mines were shut down completely; some of them were dismantled. A few of the American tungsten companies kept their mines and mills in readiness, hoping that the Timberlake bill,[1] imposing a tariff of $10 per unit, would become a law. But the year again closed and the bill had not been signed. Although the country was still overstocked with tungsten concentrates and there was virtually no demand, new shipments of cheap Chinese and Bolivian ores continued to arrive during the year at our ports, thus postponing the reopening of our own mines. Germany, having depleted her stores during the war and not being able to produce enough tungsten in Saxony to satisfy the demands of her steel industries, welcomed the cheap Chinese ores to her ports. The question soon arose in America and in England whether a tariff on concentrates and metal would really save and protect the home industries. Those most intimately acquainted with the situation felt that the United States tungsten mines would not return to anything like pre-war production until the surface deposits of Asia, which required a minimum of expense to mine, had been exhausted. Both in this country and abroad much time was devoted to the subject of deep mining, believing that deep mining would help to stabilize the tungsten mining industries.[2]

In the table below the production of the United States is given in short tons of concentrates of 60 per cent. of tungstic acid, WO_3, which is the commercial basis in this country. (In Great Britain it is 65 per cent. WO_3).

PRODUCTION OF TUNGSTEN CONCENTRATES IN THE UNITED STATES (a)
(In tons of 2000 lb., 60 per cent. WO_3)

Year.	Production.	Value.	Average per Ton.	Year.	Production.	Value.	Average per Ton.
1911.....	1,139	$407,985	$358	1916.....	5,923	$12,075,400	$2,040
1912.....	1,330	502,158	377	1917.....	6,144	6,783,400	1,100
1913.....	1,537	672,118	438	1918.....	5,061	7,049,300	1,393
1914.....	990	435,000	439	1919.....	935	504,900	540
1915.....	2,332	4,100,000	1,760	1920.....	216	109,300	500

(a) F. L. Hess, U. S. Geol. Surv. 1919 and 1920 values are estimated.

[1] "Tungsten Ores," Chas. B. Timberlake, Hearings before the Committee of Ways and Means, House of Representatives, on H. R. 4437; also, U. S. Tariff Commission, Washington D. C., Information Series 21, "Readjustments of Certain Mineral Industries affected by the War."

[2] See under *England* and *Saxony-Bohemia*.

The price per unit of 60-per cent. concentrates was $7.50 to $10 at the opening of the year, but by the middle of the year the price dropped to $5.00 per unit and at the close of the year it was difficult to consummate sales even at $4.00 and $3.50 per unit.[1]

Tungsten Imports into the United States

In the past about 50 per cent. of the tungsten consumed in this country was of foreign origin, but in the last two years over 80 per cent. of our consumption was foreign tungsten. The imports of concentrates (65 per cent.) totaled 10,365 long tons in 1918, valued at $11,413,414, as compared with 749 tons valued at $362,422 in 1912.[2] These figures clearly indicate the remarkable development of the tungsten industry in this country. The development is due to a large extent to the rapid growth of our automotive and allied industries. The official import figures for 65-per cent. ore for the years 1919 and 1920 are given in the table below:

TUNGSTEN ORE IMPORTS INTO THE UNITED STATES

Country.	1919.		1920.	
	Long Tons.	Value.	Long Tons.	Value.
Argentina	130	$111,489	77	$64,284
Chile (mainly Bolivian origin)	880	685,414	130	74,906
Peru	385	299,101	41	18,765
Japan	756	856,017	114	98,723
China	5,547	3,873,553	1,142	419,414
Other countries	702	435,619	236	103,501
Total	8,400	$6,261,190	1,740	$779,593

The imports of ferrotungsten and tungsten metal amounted to 1,997,719 lb. in 1920 valued at $1,180,829, as compared with 396,460 lb. in 1919. According to Roy C. McKenna, Latrobe, Pa.,over 50 per cent. of the high-speed steel consumed in the world is consumed in the United States.

The exports of tungsten metal and ferro-alloy totaled 4989 lb. valued at $5913, compared with 38,130 lb. valued at $113,276 in 1919.

The consumption of tungsten in the United States in 1920 amounted to an equivalent of about 4000 tons of 60-per cent. concentrates. Converting for sake of convenience the ferrotungsten and metal stocks into 60-per cent. concentrates, we had on hand at the beginning of 1920 about 12,000 tons; add to this the imports of ore and metal and Colorado's production and deduct the 4000 tons consumed, leaves a net balance of

[1] Compare for further details, *Eng. Min. Jour.* quotations; in particular, "Tungsten Market," by Charles Hardy, *Eng. Min. Jour.*, Jan. 22,1921.
[2] Official Statistics, Bureau of Foreign and Domestic Commerce, Washington, D. C.

over 12,000 tons at the close of 1920, which will require at least two years to absorb.[1]

United States

Alaska.—During the course of the year a detailed report on the mineral resources of Alaska appeared.[2] In it S. H. Cathcart refers to the mining of tungsten in northwestern Alaska during 1918. R. M. Overbeck comments on the occurence of tungsten minerals in the Tolovana district. For other tungsten localities in Alaska see Mineral Industry, **26,** 699 (1917) and **27,** 717 (1918).

California.—During 1920 tungsten "dropped out of the active list entirely" according to reports of State Mineralogist Fletcher Hamilton. Whereas the oil, silver, zinc, lead and magnesite industries were fairly prosperous, the tungsten, chromite and manganese industries fared very badly. California scheelite is the purest tungsten ore in the world and during the years of the war commanded a premium. In the original Papoose mine of the Atolia company the scheelite vein was 3 ft. thick. The Atolia mines closed down before the unit price dropped to $10. Although the California deposits are predominantly scheelite, there are two districts in San Bernardino County where the ore is characteristically wolframite.[3]

Colorado.—Colorado possesses the highest-grade iron tungstate, ferberite, deposits in the world. During 1920 the Boulder field was the only one that was in operation in this country. According to Hess both the Wolf Tongue Mining Co. and the Vasco Mining Co. were active part of the year. They together produced an equivalent of 216 short tons of ferberite concentrates (60 per cent. WO_3). The Primos Chemical Co., which at one time was one of the largest mining companies in Boulder County, dismantled its mines and actually went out of business in 1919. The easily mined ore in Colorado has been disposed of and a future development of the tungsten industry in the State will involve deeper mining and larger investments and costs. The veins are often narrow and the ore-shoots erratic. The average depth of the Boulder district mines is less than 300 ft. from the surface.[4]

Nevada.—High-grade tungsten ore of unusual value was struck on the property of the Kennon Mining Co. in Pony Gulch, Nevada. The mineral (probably scheelite) occurs in a vein 8 in. wide in a 5-ft.

[1] Compare Chas. Hardy, *Eng. Min. Jour.*, Jan. 22, 1921.
[2] U. S. Geol. Surv. Bull. 712, 198 pp., Washington, 1920.
[3] For full details as to the tungsten localities in California, Colorado and the other states see Mineral Industry, **26,** 699 (1917); **27,** 717 (1918); **28,** 689 (1919); also "Tungsten Ores," Hearings before the Ways and Means Committee, House of Representatives, H.R. 4437, Chas. B. Timberlake Bill, Washington, 1919; U. S. Tariff Commission Information Series, No. 21, Washington, 1920; Frank L. Hess, "Mineral Resources of the U. S., 1918," pp. 973–1026, Washington, 1921.
[4] Mineral Industry, **25,** 726 (1916).

ledge that carries $5 to $6 in gold.[1] No production for 1920 was recorded. Some interest was displayed in the contact-metamorphic deposits of Nevada and at one time it seemed as though mining operations would be resumed, but the continued drop in unit price disheartened the promoters. Nevada possesses a large number of undeveloped tungsten deposits.

UNITED STATES PRODUCTION ACCORDING TO STATES
(Short tons of 60-per cent. concentrates)

	1918.	1919.	1920.		1918.	1919.	1920.
Alaska	14	.....	.....	New Mexico	4	5*	.....
Arizona	213	30*	.....	South Dakota	201	100*	.....
California	1,791	200*	.....	Utah	3	.....	.....
Colorado	1,910	300*	216	Washington	2	.....	.....
Idaho	12	.....	.....	Other States	13	10	.....
Nevada	898	200*	.....				
				Totals	5,061	845*	216

* Estimated.

CANADA

Tungsten has been mined on a small scale in Nova Scotia, Quebec, Ontario, British Columbia and in the Yukon Territory. But the output of Canada has always been comparatively small. The biggest producer in the past has been the scheelite mines in the Moose River district of Halifax County, Nova Scotia. The deposits were discovered about 1908.[2] The scheelite is associated with quartz, mispickel, mica, feldspar and other minerals, and occurs in veins similar to those of the neighboring gold-bearing region. In 1919 Canada produced an equivalent of about 45 tons of 60-per cent. concentrates and in 1920 25 tons. In 1919 Canada exported to the United States 20 tons of concentrates valued at $12,750. There has been little incentive to develop the Canadian tungsten mining industry in the face of the cheap Chinese and Bolivian ores which the home goverment has been importing in large quantities.

MEXICO

Frank L. Hess looks upon the deposits of Mexico as a continuation of those of southern Arizona. So far as known all the Mexican deposits carry scheelite, partly replaced by cupro-tungstite. Tungsten occurs in the Nogales district, State of Sonora; near Huepec, Sonora, the scheelite is associated with copper; in the district of Sahuaripa, Sonora, 150 miles south of the Texas line, scheelite occurs together with molybdenite. Scheelite deposits have also been worked in the Yaqui River district below Tonichiari, Sonora.

[1] *Eng. Min.. Jour.*, Nov. 20, 1920; see also MINERAL INDUSTRY, **27**, 720 (1918).
[2] Sydney J. Johnstone, *Jour. Soc. Chem. Ind.*, **37**, 336R.

According to the Mexican Secretariat of Industry, Commerce and Labor,[1] Mexico's tungsten production within the last four years was as follows: 1917, 188 metric tons; 1918, 150; 1919, 22; and 1920, 35 tons. These figures do not check with U. S. Government import statistics.[2] According to these latter, the figures are: 1917, 308 metric tons valued at $176,849; 1918, 239, $224,247; 1919, 104, $104,529; 1920, 82, $12,055. These figures appear in the table at the end of this chapter.

South America

Argentina.—Tungsten and petroleum are the only important mineral products of Argentina. The tungsten deposits are largely confined to the pampa ranges, in which they are widely distributed. Both scheelite[3] and wolframite occur, but the latter has so far predominated in all shipments. The Provinces of San Luis and Cordoba have been the most important centers.[4]

The Hansa Mining Co., under German control, is the largest producer. Argentina exports practically all of the wolfram mined. The following export figures except those for 1919 and 1920, which are estimates,[5] are taken from the official export statistics of the Republic.

EXPORTS OF TUNGSTEN FROM ARGENTINA

	Metric Tons.		Metric Tons.
1910	809	1916	760
1911	584	1917	985
1912	637	1918	572
1913	536	1919	350
1914	394	1920	120
1915	158		

The entire shipments up to and including 1914 went to Germany. In 1915 and 1916 almost all the shipments went to the United States. In 1918 the United States took 479 metric tons valued at $730,722; in 1919, 130 tons valued at $111,489; and in 1920, 77 tons valued at $64,284. These concentrates averaged about 64 per cent. WO_3.[6]

The last three months of 1920 were characterized by depressed business conditions in Argentina.[7] Every indication, however, points to a sound financial condition within the country and plans for the internal development of the Republic have taken an increased impetus.

Bolivia.—L. S. Rowe and F. J. Yanes of the Pan American Union[8]

[1] *Min. Sci. Press*, Mar. 17, 1921.
[2] Practically all of the Mexican tungsten output is exported to the United States. See U. S. Tariff Commission, Information Series, Bulletin No. 21; also Hess, "Mineral Resources of the U. S., 1918," p. 1010.
[3] *Comm. Rept.*, Dec. 28, 1920.
[4] For details of the geology see Mineral Industry, **27**, 723 (1918).
[5] *Comm. Rept.*, May 29, 1920.
[6] In Boletin No. 1, Rept. Argentina Ministerio de Agricultura de la Nación, 1920, the exports for 1918 are given as 563,257 kg., 65 to 70 per cent. WO_3.
[7] Geo. S. Brady, *Comm. Rept.*, Apr. 13, 1921.
[8] "Commerce of Bolivia in 1919," Washington, D. C., 1921.

report that in 1919 1995 metric tons of 65-per cent. tungsten concentrates valued at 3,246,501 bolivianos (1 bol. = 39 cts. U. S.) were exported from Bolivia, as compared with 3418 tons valued at 10,591,429 bolivianos in 1918. These exports were distributed as follows: In 1919, to United States, 1386 tons; to Great Britain, 390 tons; and to France, 210 tons. The corresponding figures for 1918 were 2539 tons, 554 tons and 321 tons.[1]

The closing down of the mines which had started in 1919 continued into 1920 and by the middle of the year practically all mining of tungsten had ceased and the concentrates produced were largely by-products of the tin mines. These by-products totaled about 200 metric tons of 65 per cent. WO_3, as compared with 3890 tons in 1917 when the tungsten industry was at its height. About 160 tons of Bolivian 65-per cent. concentrates were shipped to the United States in 1920.

Bolivia shipped through the Chilean port of Arica 227 metric tons of 65-per cent. ore valued at 391,317 pesos, of which 133 tons reached the United States. Thirty tons went to France, 9 to Great Britain and 56 tons to Germany.[2] Bolivian concentrates were also shipped through Mollendo, Peru.

The most important tungsten districts of Bolivia are La Paz, Oruro, Potosi and Cochabamba. The output of La Paz has been equal to that of the three others put together. The principal mines of La Paz are the fields of Palca or Yungas, and Quime or Inquisivi. In the Oruro district are some important scheelite deposits at Conde Auque. In the Cochabamba district the principal mines are at Khami and Chicote. At Salasala in the Uyuni district huebnerite of exceptional purity has been produced. In general, Bolivian wolframite occurs in quartzite and granite.[3]

The property of the Empresa Minera Pacuni Blanca N. Dillon, located on the southern slope of the Serronia de Pacuni, Quimza Cruz region, was acquired by Guggenheim Bros., New York.[4] The veins are wolframite and at the height of the tungsten boom in 1917 the mine produced 35 to 40 tons of 70 per cent. WO_3 and 2 per cent. tin concentrates per month. According to Singewald, the principal veins are the Blanca and the Inca, which run nearly parallel to the main system of sheeting in the granite. The Blanca vein averages 2 to 2.5 ft. in width. The filling is chiefly coarsely crystallized quartz and wolframite, with a little tourmaline and pyrite. The average grade of the Pacuni ore is given as 12 per cent. WO_3. Comparatively little is known of the vast

[1] Bolivia shipments are made either via Chile or Peru and consequently the United States import figures as recorded at our ports are apt to be misleading. Chile has no tungsten industry. The above figures by Messrs. Rowe and Yanes are based on official Bolivian export records.
[2] *Comm. Rept.*, Apr. 4, 1921.
[3] For further mineralogical and geological details see MINERAL INDUSTRY, **28**, 692 (1919).
[4] J. T. Singewald, Jr., *Eng. Min. Jour.*, Nov. 20, 1920.

mineral wealth of Bolivia. Many parts of the country have been unexplored for centuries.

Peru.—The tungsten industry of Peru has been largely in the hands of the Germans for a good many years. Prior to the war about 60 per cent. of all tungsten exported from Peru went to Germany.[1] The mineral is chiefly huebnerite, and the important mining districts are Conchucos and Corongo. The Huaura deposits are considered very extensive.

During 1919, 248.5 tons of concentrates, 63 per cent. WO_3, were exported from Peru, about half Peruvian origin.[2] In 1918 the official production report[3] distributes the output as follows: Department of La Libertad, 124.4 metric tons, 65 per cent.; Ancacho, 111.8 tons, 61 per cent.; Huancavelica, 5.9 tons, 65.3 per cent.; and Puno, 0.9 tons, 60 per cent. L. S. Rowe[4] gives the tungsten production of Peru for 1919 as 113,566 kg. valued at $54,170 U. S. gold; or 129 tons (63 per cent.) at 14,120 libras in 1919, as against 243 tons, 60,020 libras in 1918. In 1920 the industry received a severe setback and only 60 tons[5] was produced. Peru shipped 41 tons valued at $18,765, partly of Bolivian origin, to the United States in 1920.

Europe

England.—E. H. Davison published a highly interesting account of the geology of the wolfram lodes of the West of England.[6] Since 1903, wolframite has been an important by-product of many tin mines. Scheelite is found in two localities, but only in very small amounts. Cornwall and Devon are built up of Palaeozoic sediments and all are predominantly slaty. These sediments are penetrated by five large granite bosses, each surrounded by a zone of contact alteration. Lodes occur both in the granite and in the altered clay-slate around it. The three metals, tin, tungsten and copper are differently distributed in the lodes, the upper parts carrying either predominant copper or tungsten, while tin becomes predominant in depth. The tungsten is found chiefly in those lodes which lie close to the granite-slate contact; these lodes, in addition to quartz, commonly contain mispickel and cassiterite; the gangue minerals usually include chlorite and feldspar, while tourmaline and fluorspar are also often present. The structure of the tungsten lodes is usually coarsely crystalline. The chief working areas are: Godolphin, Carn Menelez, St. Austell, Kitt Hill and Dartmour.

[1] See Mineral Industry, **28**, 693 (1919).
[2] *Comm. Rept.*, Mar. 18, 1921.
[3] *Estadistica Minera en* 1918, Carlos P. Jiminez, Lima, 1920. Boletin 99, pp. 137 and 138.
[4] "Peru," *Pan American Union*, Washington, 1921.
[5] Preliminary estimate.
[6] *Mining Mag.*, Oct., 1920.

The Castle-an-Dinas tungsten mine lies about 2 miles east of St. Columb, West Cornwall.[1] The mine yields a "remarkably clean" tungsten ore. The lode is a practically vertical fissure in the Meadow foot slate and was until 1920 worked by two adits driven into the hillside. The width of the lode varies from a few inches to about 3 ft. There are very seldom foreign minerals encountered in the lode filling; a little copper and tin, of which the latter in the concentrates runs less than 0.3 per cent.[2] In the country rock the tin averages 1 per cent. and here too there is much tourmaline, whereas the lode is practically free from it. On the other hand the veins of the Kitt Hill mine, Callington, contain cassiterite, tourmaline, molybdenite, and mispickel.

Dr. Malcolm Maclaren in reporting on the central mines[3] of the Camborne-Redruth area pointed out that "the prime factors governing the deposition of ore, whether tin, tungsten, copper or arsenic, have obviously been temperature and pressure, and the latter is probably of subordinate importance. The metalliferous solutions were sufficiently chilled while rising through the upper zone of the granite to permit of the deposition of the tin and tungsten, but they were still hot enough to carry upwards the copper and arsenic minerals until the cold killas (slaty rock) abstracted sufficient heat to permit of their deposition in turn." Certain mines in the Camborne-Redruth area which were abandoned when their copper production failed may be found to be valuable tin-tungsten producers if developed at lower level.

As in the United States, so also in England, although not as early in the year, the tungsten industry suffered badly from the general business depression. By the end of 1920 practically all of the Cornwall mines owned by public companies had closed down.[4] The report of East Pool and Agar mine near Camborne showed a loss for 1920 of £28,007. This loss was entirely due to the fall in the price of tungsten, tin and arsenic and the increase in the cost of coal, materials and labor. The mine has never looked better and new discoveries of high-grade ore have added substantially to the reserves. The production for 1920 of this company was: tungsten concentrates, 46.8 tons (£1024); tin concentrates, 874 tons (£152,015), and arsenic, 500 tons (£22,728); making a total of £175,767, or 47s. 3d. per ton of ore milled. England's total tungsten concentrate production in 1920 was equivalent to about 140 metric tons on the 60-per cent. basis, as against 183 tons in 1919[5] and 427 tons in 1916.

The Key Industries Bill covers metallic tungsten, ferrotungsten and manufactured products of metallic tungsten and compounds of the rare-

[1] E. H. Davison, *Geolog. Mag.*, Aug., 1920.
[2] In the United States this is considered very high.
[3] *Queensland Govt. Min. Jour.*, Sept., 1920.
[4] *Mining Mag.*, March and April, 1921.
[5] *Comm. Rept.*, July 21, 1921.

earth metals. "For a period of five years after passage of bill[1] a customs duty of 33⅓ per cent. ad valorem on these imports into Great Britain and Ireland." During the year there was considerable agitation regarding a protective tariff on ores, similar to the one proposed in the United States. The British Government felt, however, that any attempt to tax cheap Chinese ores would simply drive them to Germany and thereby handicap the British trade and industry as well.

France.—Wolframite with cassiterite occurs in the departments of Allier, Haute Vienne and Cantal in central France, and in the department of Ille-et-Vilaine, in east Bretagne; scheelite occurs in small quantities in the Vosges Mountains. France obtains most of her native supply from Tonkin, French Indo China (q. v.);her production at home has been comparatively small, only 33 tons in 1919 and 6 tons in 1920.[2] France has within recent years imported large quantities of foreign tungsten ores, notably from Portugal; in 1919 these imports approximated 1000 metric tons. The demand for tungsten in France has been increasingly large due to her rapidly developing iron and steel industry (see under "Iron and Steel," this volume). The motor-car industry is one of the most important branches of French metallurgy and, as has been pointed out before, this industry is almost impossible without tungsten steels.

Italy.—With the acquisition of the Trentino, Italy came in possession of wolframite deposits at Bedowina, in the neighborhood of Predazzo. The deposit is estimated to contain 180,000 tons of ore containing 450 tons of tungstic acid and 2160 tons of copper.[3]

In the antimony deposits of Sardinia tungsten occurs as scheelite.[4]

Portugal.—Portugal is the chief tungsten producer in Europe. The mineral is mostly wolframite and huebnerite, in quartz veins of the fissure type cutting both granites and schists. The principal mines are the Borralha in Tras Os Montes, the Panasqueira in Beira Alta, the Moimenta, the Montado de Adoria and Cabeco de Paredes.[5] There are but few deep mines. The ore is generally associated with lead, zinc or iron sulphides in the veins. In 1917 Portugal produced an equivalent of almost 1600 tons of 60-per cent. concentrates, but since then the industry has been on the decline. The output is largely controlled by Great Britain, France and Germany. According to the latest data available[6] the production in 1919 totaled 770 metric tons (65 per cent.) as against 1300 tons in 1918. Of the 770 tons 697 went to France and 47 to Spain.

[1] Not passed in 1920.
[2] *Annales des Mines*, **3, 11**, 318 (1921).
[3] *Min. Jour.*, Feb. 19, 1921.
[4] MINERAL INDUSTRY, **26**, 727 (1918).
[5] MINERAL INDUSTRY, **27**, 727 (1918).
[6] W. L. Lowrie, *Comm. Rept.*, Nov. 3, 1920.

There is no consumption of tungsten in Portugal. The production of 1920 is estimated at 200 tons.

Russia.—The Bureau of Foreign and Domestic Commerce published a report[1] on the tungsten deposits in Russia.[2] Tungsten is found in the Boyev mines, near the Kamenski Works, Kamyshlov County, Province of Perm. The Russian Mining Bureau reported a production of 108 tons of 60-per cent. concentrates in 1917, but since then no definite figures have been published. Tungsten was discovered in Asiatic Russia in 1911–12, in the Nertchinsk region, Transbaikal Province; the beds are only partly explored. Mines are located near the Khara-Nor station of the Transbaikal railroad, on the Bukuka Mountain, on the Sherlov Mountain and near the village Oldanda, 40 miles east of the Bordza railroad station. Before the war the production of the Bukuka mine was equivalent to 24 tons of 60-per cent. concentrates per annum. The main product of the Sherlov mine consists of topazes and aquamarines. Tungsten minerals have also been met with in the Kolyvan mines and Zmeinogorsk mines, Altai, in the south of Batum and near the source of the Solgutidon Creek, Caucasus.

Saxony-Bohemia.—Tungsten-tin ores have been mined in the Erzgebirge, bordering between Saxony and Bohemia, ever since 1240. During the war efforts were made to increase the production of the two metals from this district in spite of the comparatively low tenure and the high cost of mining and milling. Previous to the war Germany and Austria had imported practically all of their tungsten from Burma, South America and Portugal.[3]

Among the most important localities of the Erzgebirge area are Zinnwald, Altenberg, Sadisdorf, Schlaggenwald, Schoenfeld (near Eger) and Falkenstein. The ores are usually very complex: besides cassiterite and wolframite there are often present considerable quantities of other minerals, such as tourmaline, psilomelane, chalcopyrite, arsenopyrite, molybdenite, bismuthinite and scheelite.

The first authentic production figures for Saxony since 1913 were published by the German Government in *Glückauf* for Mar. 12, 1921, as follows: 1913, 96 metric tons; 1914, 108; 1915, 78; 1916, 105; 1917, 151; 1918, 199; 1919, 250. The WO_3 content is not stipulated, but this is probably 70 per cent.[4] Accordingly, the Saxon output of tungsten concentrates in 1919 on the 60-per cent. basis was approximately 290 metric tons. The production for 1920 we estimate at about 150 tons for Saxony or 170 tons for Saxony and Bohemia together, as the demand

[1] *Comm. Rept.*, Sept. 18, 1920.
[2] See also MINERAL INDUSTRY, **25**, 735 (1916); **26**, 712 (1917).
[3] *Met. Chem. Eng.*, Sept. 15, 1917, p. 272.
[4] MINERAL INDUSTRY, **28**, 695 (1919).

for the concentrates was comparatively small during the second half of the year.

During the course of the year Anton Frieser made public his studies of the tin-tungsten deposits of the Schoenfeld-Schlaggenwald district.[1] Frieser reports that in the Wilhelm shaft rich deposits were still met with at a depth of 150 meters, the veins extending from the gneiss into the granite below. Mining engineers feel very much encouraged at the prospects of finding tin and tungsten at depths formerly considered valueless.

Spain.—Tungsten occurs in the provinces of Zamora, Pontevedra, Salamanca, Badajos, Orense, Coruña Cáceres, Córdoba, and Almeria. Many of the mineral deposits of Spain are far from being exhausted and only await the necessary capital, machinery and aggressive action to make them successful investments. The latest official published production figures are those for 1918,[2] when an equivalent of 580 metric tons of 60-per cent. concentrates was turned out, valued at 2,457,357 pesetas.[3] The four largest producing provinces were Badajos, Cáceres, Orense and Pontevedra. The production of tungsten concentrates in 1919 is estimated at 337 metric tons (65 per cent.) valued at 234,600 pesetas (at normal exchange, 1 peseta = 19.3 cts.),[4] or an equivalent of 365 metric tons of 60-per cent. WO_3 concentrates. The production for 1920 is estimated at 150 tons (60 per cent.).

Asia

Billiton Island.—This is one of the Dutch East Indies. The tungsten deposits belong to the same metallogenic province as Tonkin and Burma. The main output of the Billiton Maatschappy's mine is tin, with wolframite concentrates as a by-product.[5] In 1919 150 tons of wolframite concentrates was produced. The output for 1920 is estimated at 50 tons of 60-per cent. concentrates.[6] The average analysis of the ore is about 2.5 per cent. tin and 1.0 per cent. tungsten.

Burma.—In the three years preceding the war, the annual production of tungsten concentrates in Burma amounted to about 2000 metric tons, or about twice that of the United States. During the war the production was more than doubled, but with the signing of the armistice the demand for the metal rapidly dwindled and although the Burmese industry was subsidized by the home government (London), at the end of the third

[1] *Berg und Hüttenmännisches Jahrbuch*, **68**, 49 (1920); see also Mineral Industry, **28**, 695 (1919).
[2] *Estadistica Minera de Espana*, ano 1918, Madrid, 1919.
[3] As regards the misprint in the Spanish tables, see F. L. Hess, "Mineral Resources of the United States, 1918, p. 1001.
[4] *Comm. Rept.*, Apr. 28, 1921.
[5] *Eng. Min. Jour.*, Dec. 4, 1920.
[6] See Mineral Industry, **28**, 696 (1919).

quarter of 1919, practically all operations in the tungsten areas ceased and miners turned their attention to tin. According to E. Maxwell Lefroy, retiring president of the Tavoy Chamber of Commerce, there were 2556 tons of mixed tin-tungsten concentrates produced in Burma during 1920.[1] He states that the final revised figures will actually be much larger, probably about 2800 long tons. It is estimated that over 2200 tons of tungsten concentrates (65 per cent. WO_3) was produced. One of the companies turned out 1730 tons of mixed tin-tungsten concentrates. Lefroy further reports that during the 12 years 1907 to 1919 Burma shipped a total of 21,454 long tons of mixed concentrates valued at Rs 3,90,28,584, and says that doubtless wolfram will again reach 30 shillings a unit before July, 1922, but that leaves only a small margin of profit to the richer properties. By the close of 1920 all the tungsten mines except the High Speed Steel closed down and only mines with mixed concentrates were being worked, and these for tin only, the tungsten contents being stacked.[2]

The stock of mixed tin-wolfram concentrates of the Mawchi Mines, Ltd., amounted to 939 tons by the close of the year. In addition, 473 tons of mixed concentrates was awaiting shipment.[3] The Survey Department made a one-inch survey of the country.

The important tungsten centers are Tavoy, Mergui, Moulmein and Thaton; tungsten is also found in the Southern Shan States. The Tavoy lodes are usually quartz with a little mica. The tungsten and tin minerals arrived in the lodes by some means or other from the cooling granite magma. Pyrite and other natural sulphides are usually associated with the wolframite and cassiterite found in Burma.[4] According to Vice-Consul Chas. H. Thorling[5] the production of 65 per cent. WO_3 in metric tons during 1917 to 1919 was as follows:

	1917.	1918.	1919.
Tavoy	3,697	3,636	2,889
Mergui	368	377	194
S. Shan States	365	334	462
Thaton	107	96	32
Total	4,537	4,443	3,577

The average rate of production during 1919 was higher than prior to 1916.

China.—The Chinese tungsten deposits dominate the world. The very low cost of mining and shipping of Chinese wolframite is directly

[1] *Min. Jour.*, Feb. 26, 1921.
[2] *Min. Jour.*, Mar. 5, 1921.
[3] *Mining Mag.*, Apr., 1921.
[4] For further geological details see MINERAL INDUSTRY, **26**, 713 (1917); **28**, 697 (1919).
[5] *Comm. Rept.*, Apr. 4, 1921.

responsible for the crippling of the United States tungsten industry, as was pointed out a year ago.[1] But in spite of low cost of production, tungsten mining in China received a setback during 1920 on account of the absence of any appreciable demand for the concentrates. The imports of Chinese tungsten concentrates into the United States during 1920 amounted to 1142 metric tons valued at $419,414, as compared with 5547 tons valued at $3,873,550 during 1919 and 10,362 tons valued at $11,409,237 in 1918. The total production of China for 1920 is estimated at 4200 metric tons, 65 per cent. WO_3, equivalent to 4550 metric tons of 60-per cent. concentrates.

During the first nine months Canton shipped 3280 metric tons of 65-per cent. ore and Hongkong 900 tons. [2]

Tungsten is found in the Hunan Province, Kiangsi Province, Kwangtung Province and Chili Province.[3]

The great advantage possessed by China is the ready accessibility of the deposits, which occur in surface detritus, such as hill wash and stream deposits, where natural concentration has taken place in the vicinity of lodes.[4] According to Harwood Keppel,[5] the great mass of China's tungsten resources is as yet untouched, and the best fields or deposits were just coming into working when the collapse of the war trade came. One field discovered in July, 1918, was producing, at the height of the demand, 1200 tons of ore per month, and the possibilities of its development on an economical, scientific, and normal basis are indicated by the fact that the shipments of ore out of South China were made profitably at about one-third the price realized from the later shipments.

The new field centers around Sai Wah Shan, in the vicinity of Nannanfu, in Kwangsi Province, not far from the Kwantung Province boundary line. Practically all of this ore is taken from public or semi-public lands—*i.e.*, lands owned in common by the people of neighboring villages—and the work is done either by the villagers or by Chinese capitalists working under an arrangement with the people of the villages. Therefore, though the market collapse affected all the people concerned in the trade who had ore on hand at the time, it involved no expensive plant and little permanent investment.

In the fall of the year (1920) new tungsten deposits were uncovered in the northeastern section of the Province of Chili near Tongtshan.[6] The Chinese Government has taken charge of the exploitation of the deposits. A large smelter for the production of ferrotungsten has been seriously considered.

[1] MINERAL INDUSTRY, **28**, 699 (1919).
[2] *Queens. Govt. Min. Jour.*, Apr., 1921.
[3] For further details see MINERAL INDUSTRY, **28**, 699 (1919).
[4] *Brit. Chamber of Commerce Jour.*, March, 1920.
[5] *Eng. Min. Jour.*, Feb. 12, 1921; see also *Min. Jour.*, May 29, 1920.
[6] *Far Eastern Rev.*, Jan., 1921.

Federated Malay States.—Wolframite and scheelite occur in the states of Perak, Selangor, and Negri Sembilan. The production of Pahang has been comparatively small. Of the total exports, 5971 piculs (1 picul = 133 lb.) of tungsten concentrates in 1918, 4097 piculs was wolframite and 1874 piculs was scheelite concentrates.[1] The production for 1918 amounted to about 370 metric tons (60 per cent. WO_3), as compared with 750 tons in 1917. The production in 1919 amounted to 7323 piculs or about 550 metric tons of 60-per cent. concentrates.[2] During 1920 the tungsten industry of the F.M.S. had to combat high wages, high cost of machinery and fuel, difficulty in obtaining fuel, and a rapidly decreasing price for the product. A number of mines had to close down altogether.[3] The production of 1920, however, showed much less decline than might have been expected. The total yield was 6345 piculs. Exports, however, were considerably lower, only 3399 piculs being shipped while 2421 piculs remained in stock.

At Bukit Rumpian in Perak are some of the best-known lodes. Here the country rock is tourmaline granite traversed by small quartz veins carrying both tin and tungsten. Scheelite is found at Kanching and near the Batu caves.

Unfederated Malay States.—These states, Kedah, Trengganu and Johore, are situated in the same peninsula as the Federated States. During the war years there was a very remarkable growth in the tungsten industry. In 1913 the production was but 125 metric tons, in 1916 325 tons, and in 1918 1170 tons (60-per cent. basis).[4]

Mines are located on the Dungun River and in the Kemaman district, Tregannu, at Sintok and at Ayun, Kedah. The original concentrates are often highly complex, containing besides wolframite and cassiterite iron and arsenical pyrites. During 1919 the industry began to feel the effect of a drop in the demand for tungsten and in 1920 many of the mines had to shut down. The preliminary estimate for 1919 output is 800 tons of 60-per cent. concentrates, and for 1920 200 tons.

French Indo China.—The most important producing state is Tonkin, in the north, bordering on China. The tin-tungsten mines of Tonkin are located in the granite massif of the Pai Oac, about 10 kilometers west of Nguyen Binh. The most important lode workings are on the St. Alexandre and Robert concessions.[5] The mineral is wolframite associated with cassiterite. Tonkin produced 333 metric tons in 1915 and 450 tons in 1918.[6] During 1919 the mines were partly idle and in 1920 the production dropped to 50 tons (preliminary estimate). The

[1] *Eng. Min. Jour.*, **109**, 1166 (1920).
[2] *Comm. Rept.*, Dec. 28, 1920.
[3] *Min. Jour.*, Jan. 24, 1921.
[4] See MINERAL INDUSTRY, **28**, 700 (1919); and *Min. Res. of the U. S.*, 1918, p. 995.
[5] See MINERAL INDUSTRY, **28**, 701 (1919).
[6] F. L. Hess, Bull. U. S. Geol. Surv., Mar. 21, 1921.

output of the colony could easily be brought up to 500 to 1000 tons of concentrates per annum, compared with which the output of France proper is insignificant. But the prospects of an increase in production within the next year or so are not particularly bright.

Japan and Possessions.—During the last three years of the war, Japan's tungsten production was at the rate of about 1500 tons per annum. Although most of this was exported, an ever-increasing proportion has been consumed at home due to the marvelous development of Japan's steel industry. In Japan proper wolframite and scheelite occur in Yamaguchi Ken and in Ibaraki Ken. In Chosen ferberite is found at Kurasawa in the Province of Kai and huebnerite at Nishisawa in the Province of Shimotsuke. Chosen shipped large quantities of scheelite concentrates from Neigetsu to Liverpool. The principal Japanese tungsten mining companies are: in Yamaguchi, Tanaka Mining Co., Awamura Mining Co., Kyoichi Sadanaga, and others; in Ibaraki, Mitsubishi Mining Co.; in Gifu, Yebisu Mining Co. and Mitsui Mining Co.; in Okayama, Koeki Shokusan Co.[1]

As in other countries, the tungsten industry of Japan experienced a severe setback during 1919 and 1920. The total production of the Empire and possessions amounted to 850 metric tons (60 per cent. WO_3) in 1919 and only 120 tons in 1920[2] as compared with 1700 tons in 1918.

The exports of wolframite concentrates of the Empire, according to official Japanese reports, were 1418 piculs valued at 88,082 yen in 1920 as compared with 10,570 piculs, 1,033,163 yen in 1919, and 19,989 piculs, 2,821,934 yen in 1918.[3]

Siam.—The chief wolframite deposits occur in the district of Nakawn Stritamarat; from here the concentrates are transported to the ports, Bangkok and Singapore. Scheelite lodes and alluvial deposits have been found in the Province of Trang, in the Aniphurship of Hoyoet. According to Frank L. Hess, Siam seems to be a country which should give an increased production, as the mines are comparatively new, and there still should be opportunity for discoveries. Consul C. C. Hansen at Bangkok in his annual Trade and Economic Review records the exports of tungsten ore in 1919 and 1920 as practically nil.[4] Tin and tungsten have been worked on a commercial scale for the last ten years. Mills with electromagnetic separators are located at Singapore. Some of the Siamese ore is shipped to Prai, F. M. S., for separation.[5]

Hansen further reports[6] that a revision of the mining laws of Siam

[1] "The Mining Industry of Japan in 1918," Japanese Bureau of Mines, Tokyo, 1919.
[2] "Monthly Returns of the Foreign Trade of the Empire of Japan," Tokyo, 1920 and 1921.
[3] Corresponding to 90, 670 and 1270 metric tons of 60-per cent. concentrates respectively. The Japanese concentrates average about 63 per cent. WO_3. The picul equals 133.3 lb.
[4] *Comm. Rept.*, July 9, 1920; Jan. 31, 1920.
[5] See MINERAL INDUSTRY, **28**, 703 (1919).
[6] *Loc. cit.*

was published in 1919 under the name of the Royal Decree Concerning Mines of the Year 2461 (1918–19). This decree defines the various forms of mining licenses that may be obtained and the general principle set forth is that all mines and minerals are Crown property wherever found, and that no mining operation can be carried on except by royal authorization.

Australia and New Zealand

New South Wales.—Tungsten occurs near Torrington associated with lead and tin. The lead is eliminated by flotation and the tin by magnetic separators. C. Lonsdale Smith described the scheelite-wolframite mines and mills of the Tungsten Mines, Ltd., situated 2 miles from Fromore and 17 miles north of Boorowa, the nearest railroad station.[1] The lodes occur in Silurian slates. The main lode has been exposed on the surface for a length of 1200 ft. In the upper workings wolframite predominated largely over scheelite, while below water-level the reverse obtains, the proportion being 5 per cent. scheelite to 1 per cent. wolframite. Bismuth occurs in relatively small quantities; iron pyrite in occasional heavy patches occurs below water-level. During 1919 and part of 1920 the ore-dressing practice of the Tungsten Mines Co. was as follows: The ore as delivered passed over a grizzly and then to an Acme 12 by 6-in. rock breaker, then into the battery hopper fitted with three rack-doors delivering to three Challenge ore-feeders. Each Nissen stamp is provided with a self-feeder, as is also the 5-ft. Huntington mill. Wire-woven screens with 196 holes per sq. in. were used. The pulp from the stamps and Huntington mill went to a hydraulic classifier and overflow from classifier to settler. The classified ore was then passed on to two Wilfleys and one Card table, the seconds from these being de-watered and treated on a Frue vanner. All the tailings were sent by launder to a V-box with discharge-pipe at the bottom for coarse sands, while the overflow discharges the slimes into a distributing box at the head of the strakes. The strakes are 30 ft. long by 11 ft. wide overall, and divided into partitions the width of a cornsack. Good second-hand cornsacks were used; the side-stitching is ripped down and the bag is laid full length. When the bags are sufficiently charged, each 30-ft. length is hosed down in turn and the slimes are allowed to settle in a box before the surplus water is drained off. By careful attention to these bag-strakes, the usual loss of slime scheelite is greatly diminished. Other ore-dressing appliances in use are a hydraulic cleaner, square and round buddles, and a kieve, or tossing tub. The round buddle in particular is invaluable for dressing the slime product from the strakes. Experiments made in calcining

[1] *Mining Mag.*, Sept., 1920.

low-grade concentrates consisting of heavy iron pyrite and fine scheelite wolfram with subsequent re-treatment, show that a high-grade concentrate can be produced by this process. Crushings of 577 tons yielded 10½ tons of concentrates, but the drought conditions which affected most of the N. S. W. mining districts forced production to cease in February, 1920.

The tungsten industry during the greater part of 1920 was badly handicapped by drought, industrial troubles, and by a rapid decline in the metal market.[1] The total production of the year is estimated at 50 metric tons of concentrates (calculated to 60-per cent. basis), as compared with 280 tons in 1918. The production in the past has been about equally divided between scheelite and wolframite.[2] The Damfino Syndicate of Bakers Creek Gorge has been the most prominent scheelite producer. The main wolframite shipments have been made by the Rockvale Wolfram Mines, at Tungsten; the Carter lode is said to be from 8 to 17 ft. wide, running about 2 per cent. tungstic acid. During 1918 the Rockvale company milled 2739 tons of crude ore and obtained therefrom 30.3 tons of concentrates valued at £5,445.

Northern Territory.—During the war this State turned out from 150 to 250 tons per annum, but during 1919 mining activities began to wane and in 1920 the output did not reach 50 tons.[3] The mineral is mostly wolframite; scheelite is also met with, but only in small quantities.[4]

Queensland.—The tungsten deposits of Queensland are confined largely to the Cairns hinterland. The most important fields or districts are those of Chillagoe and Herberton. The common mineral is wolframite, but scheelite is also found in a number of localities and at times is associated with wolframite. In the Chillagoe field much of the wolframite is accompanied by bismuth and a mixed tungsten-bismuth concentrate is shipped.

Throughout the year 1919 Queensland enjoyed the benefit of a continuance of the war price and thus Queensland possessed an advantage over other tungsten-producing countries.[5] On Mar. 31, 1920, however, the Government arrangement for the acquisition of wolframite and scheelite concentrates at 52s. 6d. per unit terminated and the effect on the industry was readily apparent even though at the same time restrictions were removed against the free export of tungsten to any country in which a market could be found.[6] By the middle of the year 1920 practically all wolfram operations ceased. The shipments amounted to 110 metric tons (65 per cent. WO_3) valued at £17,517 during the first half of

[1] *Indust. Aust. Min. Stand.*, Feb. 24, 1921.
[2] New South Wales Dept. of Mines Annual Rept., 1918.
[3] *Comm. Rept.*, May 26, 1921.
[4] Frank L. Hess, *Min. Res. of U. S.*, 1918.
[5] *Min. Jour.*, June 19, 1920.
[6] *Queens. Govt. Min. Jour.*, Apr., 1920.

the year and 1 ton valued at £125 during the second half.[1] Out of the total of 111 metric tons of concentrates, 79 tons were straight wolframite concentrates and 29 tons part of mixed tungsten-bismuth concentrates. These mixed concentrates are taken as half tungsten concentrates. About 80 tons of the total was shipped from the Chillagoe field. Other producing centers in the past have been Herberton, Charters Towers, Coen & Rocky, Cooktown, Etheridge, Gladstone, Kangaroo Hills, Port Douglas and Star River.[2] The Bamford and Wolfram mines closed down on Aug. 10, 1920.[3]

QUEENSLAND PRODUCTION OF TUNGSTEN CONCENTRATES (a)
(Metric tons of 65 per cent. WO_3)

Concentrates.	1918.		1919		1920.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
Wolframite	249.6	£43,210	228.5	£40,596	79.3	£14,275
Scheelite	17.3	3,495	12.8	2,331	2.4	460
Bismuth-wolfram	114.3	18,041	139.9	18,681	58.7	5,814
Totals1(b)	324.0	£55,726	311.0	£52,267	111.0	£17,642

(a) *Queens. Govt. Min. Jour.* (b) In deriving the total 65 per cent. WO_3 production the bismuth-tungsten concentrates have been taken as half tungsten, half bismuth.

In the production of wolframite, *per se*, the Mount Carbine mine ranks easily foremost.[4] As the bottom level of the mine was developed the lodes were found to increase in width and grow richer in WO_3 content. Molybdenite also made its appearance. The future prospects of the mine are bright. The Thermo Electric Co.'s mining operations were chiefly confined to the Larkin & Wade and Forget Me Not mines. The Mistake tungsten-fluorspar mine in the Emuford district is owned by the Industrial Pigment Co., Ltd., and was operated during the year for the sake of the fluorspar.[5] The Commonwealth Government was urged by the Chamber of Commerce to take over the Cairns properties of the Thermo Electric Co.[6] in order to safeguard the supply of tungsten. It was estimated that the company's plant could be operated by the Government at about £2000 annually.[7]

Tasmania.—Tin-wolframite deposits occur at Moina in northwest Tasmania, 36 miles from Devonport. The tin-tungsten lodes are a complex of veins traversing beds of sandstone or quartzite and lime-silicate rock. The lode gangue consists mainly of quartz, topaz, fluorite and mica.[8] During 1920 the mines at Moina were shut down most of

[1] Official statistics, *Queens. Govt. Min. Jour.*, 1920 and 1921.
[2] *Queens. Govt. Min. Jour.*
[3] *Indust. Aust. Min. Stand.*, Sept. 30, 1920.
[4] *Queens. Govt. Min. Jour.*, Apr., 1921.
[5] E. C. Smith, *Queens. Govt. Min. Jour.*, Jan., 1921; see also *ibid.*, May, 1917.
[6] See MINERAL INDUSTRY, **28**, 704 (1919).
[7] *Metal Bull.*, Apr. 19, 1921.
[8] See MINERAL INDUSTRY, **28**, 705 (1919).

the time. The wolframite output totaled 71 metric tons (65 per cent. WO_3) valued at £13,626.

The King Island Scheelite mine on King Island (situated northwest of the mainland of Tasmania, but part of this State) closed down temporarily in August, 1920, after one of the most interesting careers of any scheelite mine. The scheelite-concentrate (70 per cent.) production for the year amounted to 105 metric tons valued at £17,905, or about one-half the production of 1919.[1] The total tungsten output of Tasmania proper and King Island for 1920 therefore equals 200 metric tons of 60-per cent. WO_3 concentrates valued at £31,531, as compared with 320 tons in 1919 and 440 tons in 1918.

The deposits of scheelite on King Island are contact-metamorphic. In October, 1920, tin-bearing rock was uncovered about one mile northwest of the scheelite mine. During a 4-months run at the scheelite mill 4882 tons of crude ore was treated, of an average assay of 0.835 per cent. WO_3; from this 51.85 tons of concentrates was obtained, assaying 71.19 per cent. WO_3, equal to a recovery of 90.5 per cent., including cleanup. A number of new lenses were discovered.[2] In another run 270 tons of 0.77-per cent. WO_3 ore yielded 2.5 tons of concentrates assaying 70.8 per cent. WO_3.[3] During the 6 months ending Mar. 31, 1920, the mill treated 15,823 tons of ore of an average value of 0.67 per cent. WO_3 and produced 121 tons of concentrates valued at £21,938 at a recovery of 79.5 per cent. The King Island Scheelite Co. commenced operations in July, 1917, and from then until August, 1920, raised 67,352 tons of ore, producing 612 tons of 70-per cent. concentrates.[4]

Victoria.—The Bendigo Wolfram Mines at Wedderburn were equipped with a five-head battery and Wilfley table. J. Casley, J. Burgess, F. Chatfield, M. E. Simes and F. W. Wilson are directors of the company. No production figures were published.

Western Australia.—During the first half of 1920 Western Australia produced scheelite concentrates to the value of £294 as against £196 in 1919; the wolframite output was nil as compared with £15 in 1919.[5] In November, 1920, the output of scheelite was valued at £70. The total production of tungsten concentrates of the State in 1920 was about 2.5 metric tons (60-per cent. basis), and 3 tons in 1919.

New Zealand.—According to J. W. Butcher[6] in the years prior to the war most of New Zealand's tungsten (scheelite) concentrates were shipped to Germany. The total mineral output is small compared with the pastoral products. Scheelite has been mined in the past at the

[1] *Indust. Aus. Min. Stand.*, Aug. 12, 1920, Nov. 11, 1920, and Feb. 24, 1921.
[2] *Indust. Aust. Min. Stand.*, Dec. 9, 1920.
[3] *Ibid.*, July 15, 1920.
[4] *Ibid.*, June 6 and Aug. 12, 1920.
[5] *Indust. Aust. Min. Stand.*, Aug. 24, 1920.
[6] New Zealand Official Year Book for 1919, Wellington, 1920.

gold-scheelite mines near Glenorchy, Paradise, Macrae's, Stoneburn, Hyde and Barewood, Otago; also at Wakamarina Valley, Marlborough. Milling and concentrating plants are installed at most of the centers. The principal operations have been carried out in the locality of Glenorchy, where the lodes occur in the mica schist of Mount Judah of the Richardson Range. Scheelite lodes occur at altitudes of 3500 to 5000 ft. above the lake. All the lodes developed belong to the class of replacement fissure lodes, in which a zone of country rock lying between two more or less parallel fissures has become crushed and contorted by wall-movement and more or less silicified and partially replaced by quartz and calcite containing scheelite and a little gold.[1] The Glenorchy Scheelite Co. of Lake County, Otago, and the Dominion Consolidated Co. at Wakamarina, Marlborough, have been the largest producers.

In 1919 the Imperial Government terminated its agreement to purchase all tungsten concentrates. This was followed by a rapid decline in production. Furthermore, the known deposits showed signs of depletion. Following is the official report of the Minister of Mines, Wellington, as to tungsten-ore production, all of it being exported:

Year.	Long Tons.	Value.	Year.	Long Tons.	Value.
1910	143	£15,070	1916	266	£49,070
1911	138	11,853	1917	161	28,972
1912	135	13,347	1918	169.5	37,922
1913	221	22,933	1919	130.9	29,489
1914	204	21,498	1920	10.5	1,378
1915	194	27,784			

AFRICA

Rhodesia.—Ever since 1906 tungsten has been known to occur in Southern Rhodesia. It is found as scheelite and wolframite. In the acid type of reef wolframite is the predominating mineral. In the gold-quartz-vein type of reef scheelite occurs in very fine grains, concentrating as a dull gray or white powder in front of the gold in the pan. In 1907 the equivalent of 192 metric tons of 60-per cent. concentrates was shipped. Since then the industry has lagged far behind. According to the report issued by the British South Africa Co., the output of tungsten in Southern Rhodesia during 1920 amounted to an equivalent of 19 metric tons valued at £1519, as against 22 tons at £5103 in 1919.[2]

Union of South Africa.—Wolframite occurs in small quantities in the Transvaal near Capetown and in other localities. Scheelite is met with in the tin deposits of the Stavoren Tin Mines, near Olifants River; also in

[1] J. W. Butcher, *op. cit.*, p. 587.
[2] *Mining Mag.*, Feb., 1921; *Indust. Aust. Min. Stand.*, Mar. 31, 1921.

small quantities near Leydsdorp. P. J. Stevenson of Johannesburg[1] reports that although the tin-mining industry increased by 50 per cent. in 1920 as against that of 1919 (for further details, see under "Tin," page 667, this volume), the tungsten industry disappeared entirely in 1920. In 1919 the equivalent of 4.5 tons of 60-per cent. concentrates was produced, valued at £626.

WORLD'S PRODUCTION OF TUNGSTEN ORES (a)
(Metric tons; 60-per cent. WO_3 concentrates)

Country.	1910.	1914.	1915.	1916.	1917.	1918.	1919.	1920.
North America:								
United States	1,660	900	2,120	5,400	5,574	4,573	845*	196
Mexico	.....	.....	140	159	308	239	125	160*
South America:								
Argentina	749	437	171	825	990	625	375*	130*
Bolivia	210	276	850	3,288	4,215	3,700	2,160	300*
Peru	12	213	412	532	427	256	144	60*
Europe:								
England	280	225	360	427	265	325	183	140*
France	30	145	126	162	261	212	33	6
Portugal	1,030	967	933	1,418	1,596	1,300	834	200*
Saxony-Bohemia	160	130	100	150	200	245	340	170*
Spain	155	420	500	440	525	580	365	150*
Asia:								
Burma	370	1,868	2,883	4,123	4,200	4,800	3,800	2,500*
China	.....	.....	.....	110	1,360	10,200	6,000	4,550*
Fed. Malay States	105	288	329	524	721	362	550	400*
Unfed. Malay States	17	172	159	325	334	1,170	800*	200*
French Indo-China	19	162	333	343	433	450	280*	50*
Japan and colonies	250	195	439	1,260	1,660	1,700	850	120*
Siam	.....	273	432	530	726	185	100	40*
Australasia:								
New South Wales	380	220	100	310	268	280	250	50*
New Zealand	155	250	249	310	235	197	167	13
Northern Territory	70	45	36	137	252	275	130*	48*
Queensland	1,040	435	640	460	471	358	337	120
Tasmania	70	56	112	144	286	440	320	191
Total world production	7,000	7,400	10,500	21,000	25,500	32,000	20,000	11,000

(a) Statistics reported by F. L. Hess of the U. S. Geol. Surv. and by foreign governments. The figures with an asterisk are preliminary estimates.

Genesis of Tungsten Deposits

As in 1919 so again in 1920 a series of highly important geological and mineralogical papers on the origin of tungsten minerals appeared. We have already referred to those papers dealing with specific deposits. (See under *England* and under *Saxony-Bohemia* above.) Of a more general nature are the papers presented before the British Institute of Mining and Metallurgy.[2] The problem of "what obtains in depth" was the most important point brought out in the discussion. Roy C. McKenna had emphasized formerly that the future of the Boulder field lay in deep mining. Wm. R. Jones of the British Institute believes that the deposits of the Tavoy district, Burma, where cassiterite and wolframite occur in intimate association, will be found in depth to

[1] *Comm. Rept.*, May 2, 1921.
[2] Bulletin of the Institute, March, April, May, June and Oct., 1920.

resemble the tin deposits of Siam, of the F.M.S., and of Cornwall. J. Morrow Campbell, on the basis of his investigations, believes that the great bulk of the wolframite in veins developed before cassiterite. No example of the simultaneous growth of wolframite and quartz has been observed by Campbell; nor did he ever encounter a wolframite-bearing vein that became stanniferous at depth. The pneumatolytic theory he considers very unsatisfactory in the case of tungsten deposits: "The evidence in nature is overwhelmingly in favor of tin and tungsten having been transported in a silicic-acid medium and deposited therefrom."

Technology

Tungsten Metal and Ferrotungsten.—A number of the California tungsten interests who were also financially connected with a soda-ash plant on Owens Lake, about 75 miles from the scheelite mines at Bishop, carried out experiments on the manufacture of metallic tungsten, dissolving the scheelite in fused soda ash. The experiments were conducted by Cooper Shapley.[1] The trona at $3.00 per ton is mixed with the scheelite in a ball mill; the mixture is transferred to a firebrick crucible and melted with crude oil, the flame striking directly on the charge. After solution is complete the fused mass is run into water, the sodium tungstate allowed to dissolve, the clear aqueous solution filtered off, brought to a boil and then passed into dilute muriatic acid (plus a little nitric). The precipitate, WO_3, is dried, transferred to a churn and mixed with the correct amount of gas-house carbon. This mixture is heated in a fuel-oil fired furnace for 4 hr. at 1250° C. The tungsten metal produced analyses: W, 98 per cent.; C, 0.30; Fe, 0.29; SiO_2, 0.03; Mo, 1.25; P, trace; Cu, S, WO_3, none.

A similar process is described in detail by T. Sington of Manchester.[2] European practice in making metal and tungsten alloy is likewise reported upon by Camille Matignon, who includes analyses of ores and finished products.[3] J. L. F. Vogel[4] lays stress on the importance of first roasting the tungsten ores, in particular Asiatic and Bolivian ores, before fusing with soda, in order to eliminate most of the sulphur, arsenic and phosphorus. He states that importance of freedom from arsenic may be gaged from the fact that for every pound of As_2O_3 present in the mixed acid and tungsten solution, approximately 10 lb. of WO_3 remain in solution. Vogel also publishes detailed analyses of raw materials and products, and besides gives the standard (1917) British specifications for ferro and metal, which are as follows: For tungsten powder, 96 to 98 per

[1] General Manager of the Round Valley Tungsten Mines; *Chem. Met. Eng.*, March 2, 1921.
[2] *Eng. Min. Jour.*, Apr. 10, 1920.
[3] *Chimie et Industrie*, **3**, 277–292, 422–434; *Chem. Met. Eng.*, Oct. 6, 1920.
[4] *Chem. Age*, London, **3**, 306 (1920).

cent. W, and not more than 0.5 C, 0.3 Si, 0.2 Mn, 0.05 S, 0.015 per cent. P; CaO nil, As not mentioned. For ferrotungsten, 75 to 85 per cent. W, and not more than 1.0 per cent. C, 1.0 Si, 1.0 Mn, 0.05 Cu, 0.25 Sn, 0.06 S, 0.025 P, 0.03 CaO, As not mentioned. The assay of a roasted wolframite with 70 per cent. WO_3 showed 0.06 per cent. S, 0.95 SnO_2, and 0.04 per cent. As.

As to the manufacture of high-speed steel see MINERAL INDUSTRY, **28,** 708 (1919).[1]

Magnet Steel and Other Tungsten Alloys.—Analysis of "K. S." magnet steel is given as C, 0.4 to 0.8 per cent., Co, 30 to 40, W, 5 to 9, Cr, 1.5 to 3.[2] F. A. Fahrenwald patented a corrosion-proof alloy suitable for chemical apparatus, composed of 60 parts of chromium, 20 of nickel and 20 of tungsten, with less than 1 per cent. silicon and less than 1 per cent. carbon.[3] Stellite is now made by the Electrometallurgical Co. of America.

An interesting application of calcium tungstate (scheelite) is in the new high-speed radiographic plate of Leonard Levy and T. Thorne Baker.[4] With this plate the exposure time is reduced to $\frac{1}{30}$ of that formerly possible. The plate has a coating of silver-bromide emulsion over which is placed a layer of "scheelite." The plate is extremely sensitive to ultra-violet rays.

Analytical Methods.—A number of new modifications in the assay of tungsten in ores and alloys have been proposed by C. M. Johnson, G. M. Enos, R. F. Heath and others (see under *Bibliography*). H. O. Ward dissolves his high-speed steel sample in a silver nitrate-sulphuric acid solution. J. A. Holladay's improved cinchonine method for tungsten has become standard at many of the important tungsten laboratories.[5]

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[1] Also *Iron Age*, July 3, 1919 and Feb. 10, 1921.
[2] *Electrician*, London, Dec. 17, 1920.
[3] U. S. Pat. No. 1,357,550, Nov. 2, 1920.
[4] Royal Photographic Society, London, 1920.
[5] J. A. Holladay, Chemist, Electrometallurgical Co. of America, Niagara Falls.

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URANIUM AND VANADIUM[1]

By R. B. Moore

Uranium

The production of uranium ores during 1920 was larger than in any previous year in the history of the industry. According to the United States Geological Survey the output of uranium and vanadium ores in 1920 is estimated at 33,950 short tons containing 135.4 tons of uranium (319,257 lb. of U_3O_8) and 509.5 tons of vanadium (1,819,535 lb. of V_2O_5). The approximate value, as ore, was probably about $2,363,500. The output of uranium and vanadium ores in 1919 amounted to about 11,364 short tons containing 116.7 tons of uranium (275,245 lb. of U_3O_8), and 246.5 tons of vanadium. No pitchblende was produced during 1920, but the above tonnage includes the production of uranophane from Lusk, Wyo. There is some torbenite in the White Signal district in New Mexico, but the production of ore in this locality was insignificant. There is also a small patch of torbenite in the Burro district, New Mexico, but the deposit is entirely undeveloped, and no mining operations have taken place.

All operations of the carnotite district were very active during 1920. Practically all of the ore deposits are in the hands of four operating companies. There are only two groups of claims carrying ore in quantity which have not been worked, and represent to some extent a reserve supply of ore. These are owned by Mr. C. H. Occumpaugh and Mr. John H. Overall. Most of the tonnage came from the Standard Chemical Co.'s claims along the San Miguel River, from the claims of the Radium Luminous Corporation, the Colorado Radium Co. in Long Park, and from the Gateway district. A considerable tonnage of ore, however, was produced south of Thompson's and in the district around Moab, Utah.

A full description of the ore deposits is given in Bulletin 70 of the U. S. Bureau of Mines. A more recent and more condensed account is given by Blair Burwell in *Engineering and Mining Journal*, Oct. 16, 1920.

Geology.—The La Sal Mountains divide the Utah and Colorado deposits into two rather sharply distinct fields. The Colorado deposits follow the general direction of the Dolores River, which runs almost due north and south across the Paradox Valley, and which receives the drainage of a number of small streams, of which the more important are the La Sal Creek, Roc Creek, San Miguel River, etc. These streams have cut deep

[1] Published by permission of the Director of the Bureau of Mines.

canyons with sharply precipitous sides in which are frequently exposed the outcrops of the carnotite-bearing sandstone. In a few places, such as Long Park, the outcrops are more or less covered by vegetation, soil, etc., but in this particular locality the overburden is light and drilling operations have been resorted to. In the canyons are commonly exposed the Dolores red beds (Permo-Triassic) and above the red beds the La Plata sandstones (Jurassic). The La Plata formation is overlain by the McElmo series (Jurassic), which consists largely of sandstones and clays, and the carnotite is found in the sandstone. Above the McElmo are the Dakota sandstones and conglomerates. Sometimes the overburden is 75 or 100 ft., or even more. At other places the overburden has been considerably denuded and 30, 20 or even 10 ft., is not uncommon.

Ores.—Carnotite is a canary-yellow material, and may be described as uranyl potassium vanadate containing traces of barium and calcium. This composition is fairly well represented by $K_2O.2UO_3V_2O_5 3H_2O$. This mineral in the carnotite district is, however, associated with many others, so that the ores are quite varied in character. Those of the Paradox district differ in many respects from those of Utah, chiefly in carrying larger proportions of carnotite, and, as a rule, are more yellow. Not only do they carry more uranium, but also on the average more vanadium, although individual shipments from Utah might seem higher than the average from the Paradox district. The most typical ore is a sandstone so impregnated with yellow carnotite that the color is decidedly noticeable and containing small kidneys of brown sandy clay. The kidneys constitute a considerable part of some of the ore; in many cases they are thinly scattered through the sandstone. In addition to this typical ore there are dark blue, black, and brown vanadium ores, the dark blue being lustrous when first mined, and usually carrying uranium; high-grade carnotite in "bug holes" so soft that it can be molded in the fingers; the same kind of ore crystallized with gypsum; and red calcium vanadate, some in radiated form, and some mixed with carnotite and blue vanadium ore. Much of the very low-grade ore on exposure to the air weathers to a green, rose, or yellow color, or to all three colors intermingled. In many places several ores of different types are mixed in an intricate mass; in other places the sandstone is impregnated along the lines of stratification, and there are alternate layers of carnotite and dark vanadium ore. The deposits are invariably pockets, many of which, however, are of considerable size. Fifty tons of shipping ore from a single claim is not unusual, and a few claims have yielded more than 500 tons.

When these ores were first mined, it was naturally thought the best product should be taken out first. The first shipment was made in 1898 to Denver, Colorado, and consisted of 10 tons of ore that averaged

over 21 per cent. U_3O_8. This shipment has never since been equaled in quantity and grade combined, although smaller quantities have been mined and shipped, running even higher than this in grade. Five or six years ago the average ore treated ran from 2 to 3 per cent. U_3O_8. At the present time very little 2-per cent. ore is obtainable, and most of the material produced runs from 1 to 1½ per cent. Lower-grade material may be concentrated or all the ore mined, both low-grade and what might be called shipping ore, is concentrated together instead of being hand sorted as is the usual custom. No new deposits of commercial value have been discovered during 1920 in this country.

One new uranium mineral, "brannerite," has been described by F. L. Hess and Roger C. Wells.[1] This mineral is from the Stanley Basin in the central part of Idaho, and is found in the form of grains, part of which are prisms, and most of which show a prismatic tendency. They are a brownish yellow on the outside due to weathering which extends to a depth of about the thickness of paper. Inside they are brilliant black. The composition indicates that the mineral is hydrated metatitanate of various bases, principally calcium, iron, uranium, thorium, zirconium, and yttrium.

Ore Prices.— Prices are considerably higher than they were two or three years ago. The rise is partly due to the fact that vanadium has been in great demand, and in 1920 the price of ferrovanadium was quite high. The following will give an idea of what ore of various grades was worth last year:

URANIUM AND VANADIUM PRICES IN 1920

Price per Pound of U_3O_8. Grade, Per Cent.	Price.	Price per Pound of V_2O_5. Grade, Per Cent.	Price.
1.00 to 1.24	$1.00	4.0 to 4.99	$0.75
1.50 to 1.74	1.50	6.0 to 14.99	0.90
2.00 to 2.50	2.25		
2.50 to 2.99	2.50		
3.00 to 3.49	2.75		

Another firm offers as a basic price $70 per ton for ore containing 1¼ per cent. U_3O_8 and 3 per cent. V_2O_5. For every additional ⅒th of 1 per cent. U_3O_8 present, 80¢ is added. For ⅒th of 1 per cent. below 1 per cent. U_3O_8, $1 penalty is assessed. For every 1 per cent. V_2O_5 over the original 3 per cent. $15 is added. Not very much ore is sold on any basis, as the larger part obtained is mined by half a dozen operating companies, the small miner having been largely eliminated.

Foreign Deposits

We know very little concerning what has been done during the last few years with the uranium deposits at Joachimsthal. It is practically certain, however, that the Austrians worked these mines to a full capacity in order to get radium for luminous material for war purposes. Previous to the war, however, these mines had decreased very considerably in their ore production, and it is probable that the war production was not much greater, if any, than during the few preceding years. The Cornish

[1] *Jour. Franklin Inst.*, Feb., 1920.

mines had also practically given out before the war, and this leaves the autunite deposits of Portugal and the carnotite and other uranium deposits of Australia as the only other sources of ore supply. Very little, if any, production took place in Australia during 1920. The Portuguese mines were worked to some extent. This ore is quite amenable to treatment, but is very low grade. Methods of mining and concentration probably can be considerably improved.

Dr. George F. Kunz[1] and M. Alfred Lacroix[2] have recently described uranium-bearing minerals from Madagascar. These minerals are associated with beryl-containing pegmatites, and as these pegmatites are usually decomposed, they are found in "eluvial" deposits. The minerals are titano-niobo-tantalate carrying uranium, and the principal ore has been called betafite, named after the district in which it is found. The production has been small, the exports in 1913 being 5000 kg. and in 1917, 7280 kg. There was also some production during 1920. The actual quantity is not yet available.

There have been some further discoveries of uranium ores during 1920 in Canada. One deposit is near Parry Sound, Ontario, and is owned by Mr. H. F. McQuire, who has associated with him Mr. John Galley. This ore consists of pitchblende and uranophane, and samples examined by the writer contain as much as 2 per cent. U_3O_8. The ore is in a dike, and the owner claims that the ore is found in pockets in the dike.

Another deposit of somewhat similar character has been reported at a point 170 miles north of Toronto near Kearney Township, in the Butt district of Nipissing, Ontario. This is under the control of Mr. Nells J. Halter. No production has taken place in connection with either of these deposits.

According to advice from Fortaleza, Prof. Dias da Rocha, Director of the local museum, has discovered a deposit of radium-bearing minerals in the interior of the State of Ceara, Brazil. No details concerning this deposit are available.

Uses

Uranium was originally largely used for coloring glass and porcelain. Uranium salts color glass yellow, and if added in sufficient quantity impart to the glass a beautiful color known as "opalescent." Fifteen per cent. or more of the oxide may be required to give the desired effect. It is also used in certain yellow automobile headlights, the claim being made that the light from such headlights is more efficient in throwing the rays through fog and mist than when ordinary white glass is used. Uranium is also used in ceramics for the purpose of obtaining brilliant

[1] *Eng. Min. Jour.*, Jan. 1, 1921.
[2] "Les Industries Minerales non Metalliferes a Madagascar." Address delivered at the Museum National d'Histoire Naturelle, May 2, 1920, Paris.

fireproof tints of yellow, orange, and black. The use of uranium salts for these purposes has if anything decreased during the last few years rather than increased. Uranium has also been used in steel, the claim being made that uranium will replace several times its weight of tungsten in high-speed tool steel. Two or three concerns have manufactured such steels in the past, and whereas they have had a limited sale, they have not come into general use. The production of such steels, of course, is dependent upon the efficient production of ferro-uranium. Gillett[1] and Keeney[2] have shown how ferro-uranium can be made without serious difficulty.

Uranium metal has been put to very little practical use in the past. This is very largely due to the fact that it has been extremely difficult to make pure uranium metal. There are, however, possibilities in connection with this metal that have not been taken advantage of. The average price of ferro-uranium has been from $7 to $7.50 per lb. of contained uranium.

VANADIUM

The demand for vanadium in 1920 was extremely strong. The production was greater than any year in the history of this metal. This was largely due to the increased production of the Vanadium Corporation of America, but also due to the fact that owing to the demand for radium there was a considerable amount of vanadium produced as a by-product in the recovery of radium from carnotite ores. The total tonnage from miscellaneous sources, however, was small in comparison with the production from South American ore and from roscoelite in Colorado.

The total production during 1919 and 1920 has already been given in connection with uranium. The demand for ferrovanadium was extremely strong in 1920 until October, when the market showed some weakness, and this developed during November and December until at the end of the year it was extremely difficult for independent producers to sell vanadium either as concentrates or as ferro. About the time the weakness in the market became apparent, it was difficult for various reasons for the Vanadium Corporation to ship its full tonnage from South America.

Ores.—The chief ore from which vanadium is recovered commercially is patronite, which is found at Minisragra, Peru. This ore is a sulphide of vanadium, and the mines are now owned by the Vanadium Corporation of America, successors to the American Vanadium Co. of Pittsburgh. The ore of next importance is roscoelite or a vanadium mica. The

[1] "Preparation of Ferro-uranium," U. S. Bureau of Mines Technical Paper No. 177 (1917).
[2] "Manufacture of Ferro-alloys in the Electric Furnace." *Bull. Am. Inst. Min. Eng.*, No. 140, August, 1918.

principal supply of this ore is near Placerville, Colo., the deposits outcropping at various points along the San Miguel River for a distance of several miles. These deposits were until recently owned by the Primos Chemical Co., with a mill at Vanadium, Colo., about 6 miles from Placerville, but the Vanadium Corp. of America also acquired the entire interests of the Primos Chemical Co.

Next to roscoelite, carnotite ore has furnished the largest amount of vanadium as a by-product in the extraction of radium. During 1920, on account of the high price of vanadium concentrates and ferrovanadium, it was possible to treat a lower-grade ore for radium than would otherwise have been possible. Mr. David Taylor, of Denver, constructed a small plant at Denver for the treatment of high-vanadium, low-uranium ores, and in this plant the uranium and radium were by-products, the vanadium being the main object. Vanadinite was mined to some extent, but the production was relatively small. This mineral is quite common in several of the western states, notably Arizona, New Mexico, Nevada, etc., but the deposits are low-grade, and the mineral is difficult to concentrate owing to the fact that in a considerable percentage of the deposits the vanadinite is associated with wulfenite or lead molybdate, and these two are separated with difficulty.

J. E. Conley[1] of the U. S. Bureau of Mines has shown how vanadinite can be treated for the recovery of both lead and vanadium, and also how it can be separated from molybdenum by means of lime.

Nothing has been done with the deposits of cuprodescloizite at Bisbee, Ariz., and no commercial developments have taken place in connection with the zinc descloizite near Good Springs, Nev. This ore is very difficult to treat owing to the large amount of calcite present. No matter what the metallurgical treatment involved, this calcite uses up chemicals, and it has not been possible to separate the descloizite from the calcite by mechanical methods, although the Bureau of Mines has done a considerable amount of work along this line. The orebodies are not developed, and so tonnage of this ore available is very uncertain.

In 1920, under the new management, the vanadium deposits in Peru were worked harder than ever before. The roasted ore was formerly carried on the backs of llamas to the railway. Recently, however, a six-mile railway was constructed from the mines at Minasragra to Lake Pun Run. From this point the ore can now be ferried nine miles across the lake and loaded on motor-trucks for transportation to the railway at Rincran, a distance of 15 miles. This motor-truck service will shortly be replaced by a railway connecting these two points. The production gradually increased during the year up to September, at which time the

[1] *Chem. Met. Eng.*, May 15, 1919.

monthly production was about six times the average during the last few years.

It is stated by the company that the orebody is holding up well, and that there is a large reserve of ore in sight. The average grade shipped is from 20 per cent. to 25 per cent. V_2O_5.

The plant at Newmire, Colo., was shut down Nov. 1. The Colorado Vanadium Co., which has a small mill at Sawpit, Colo., close to Newmire, suspended operations during the year. This plant also used roscoelite ore.

Foreign Ores

Outside of the deposit in Peru only one other foreign deposit has come into prominence lately. This is the property of the African Vanadium and Lead Mines, Ltd., of the Transvaal. Concerning this deposit, Dr. P. A. Wagner and Dr. B. de C. Murchand, of the Geological Survey, in the *South African Mining and Engineering Journal* of June 12, 1920, say:

> "Of the occurrences named only the Doornhoek mine has so far yielded the mineral in commercial quantities. Here vanadinite in association with cerussite, pyromorphite, minium, and massicot, is found lining cavities and vugs in the main orebody. Several of these have been encountered recently, and from the largest of these, a flat inclined cavity about 15 ft. in length, it is estimated that fully a ton of vanadinite will be recovered. The mineral occurs in small, well-formed hexagonal crystals averaging about 1½ millimeters in diameter. Its color ranges from reddish brown to ruby red, and its luster is subadamantine, being superior to that of the Kaffirskraal vanadinite to be described below."

Metallurgy

In Peru, the patronite is first roasted, and then shipped to the United States. The old method of treatment was leaching with sulphuric acid, and evaporating the acid to dryness. This gave a crude oxide which was reduced by the Goldschmidt method. Later the electric furnace was used, silicon being the reducing agent. The chief improvement during the last few years has been in substituting carbon as the reducing agent in place of silicon. This was described by Saklatwalla.[1] The author states that the carbon reduction was a failure in the past owing to the fact that a sufficiently high temperature was not reached. The Goldschmidt method of reduction with metallic aluminium gave the temperature required, and whereas silicon does not work as efficiently, a sufficient temperature was obtained in conjunction with the electrical energy put into the furnace. In order to get efficient production with carbon, it is necessary to have a localized high-temperature zone due to the electrical energy alone, this zone being preferably close to the top of the metal bath.

[1] "Development of Ferro-Vanadium Metallurgy." *Trans. Am. Electrochem. Soc.*, 1920.

By getting this condition, and by the application of a high-voltage current and a higher current density and close spacing of the electrodes, it has been possible successfully to reduce vanadium products to ferrovanadium.

The general practice with other companies has been to use silicon, but it is probable that carbon will become more and more the reducing agent in commercial operations.

Prices

The prices for vanadium remained fairly constant during 1920. Six dollars per pound was probably the average price for vanadium metal in ferro. On the other hand, the prices at times went as high as $6.50 and in the case of low-silicon and low-carbon ferro as high as $7.00. It has been stated that in a few cases small lots of specially high-grade ferro sold for an even higher figure. A high-silicon alloy is fairly well adapted to making high-speed steel in the electric furnace or for making vanadium steels in an open-hearth furnace, but it is not so well adapted to making steels carrying a high vanadium content by the crucible process. The British use the last method to a considerable extent, and, therefore, there was during the last year a strong demand for specially pure ferro, as a good deal of the ordinary product was high both in silicon and in carbon.

Uses

No specially new uses for vanadium have been developed, although the alloys with other non-ferrous metals are being investigated.

ZINC

By Jesse A. Zook

The mine output of zinc in the United States increased greatly in 1920, after declines in 1919, and the smelter output of zinc was but a little under that of 1919, according to a statement by C. E. Siebenthal, of the U. S. Geological Survey, compiled from reports and estimates by producers and others.

The recoverable zinc content of ore mined in 1920 was about 597,000 short tons, compared with 557,000 tons in 1919 and 632,243 tons in 1918. The output of the Eastern States was about 102,000 tons, that of the Central States about 343,000 tons, and that of the Western States about 152,000 tons, compared with 122,000, 305,000, and 130,000 tons respectively in 1919. The gain in the output of the Central States was made possible by an increase of nearly 50,000 tons in the Joplin district, and the gain in this district was chiefly the result of an increase in the output of Oklahoma, which reached a total of about 209,000 tons, the largest zinc output ever made by a single State, but Kansas also made a good gain, producing over 68,000 tons. In 1919 Oklahoma produced 178,410 tons and Kansas 47,626 tons. In 1920 Montana (Butte district almost wholly) apparently produced about 102,000 tons, as compared with 84,382 tons in 1919, and the New Jersey output declined to about 78,000 tons from 92,912 tons in 1919. The output of the upper Mississippi Valley was about 37,000 tons, as compared with 47,553 tons in 1919.

The imports of zinc in ore increased from 17,009 tons in 1919 to about 23,000 tons in 1920. The zinc content of ore imported from Mexico increased from 11,225 tons in 1919 to about 15,000 tons in 1920. Australia furnished ore containing 3852 tons of zinc and Canada and other countries sent smaller quantities. The zinc content of zinc ore in bonded warehouses on Nov. 30 was 25,642 tons. Some of this ore may have been smelted but not shipped, and thus may be included in smelter stocks.

In January concentrates containing 60 per cent. zinc brought in the Joplin district $60 a ton. The price soon dropped to $50, remained practically stationary for two months, then dropped to $45 or below for two months. Through the second half of July and August the price was $48, after which it fell to $40, remained at that figure through October, dropped to $30, and was still less at the end of the year.

Conditions at the End of 1920.—The low price of zinc toward the end

of the year caused a sharp curtailment throughout the country. The Franklin Furnace mines of New Jersey were operating at 50 per cent. of normal capacity, and the zinc mines of east Tennessee and the mines of the upper Mississippi Valley, where only 12 or 14 mines were in operation, at about 60 per cent. The Joplin district was mining at 60 to 70 per cent. of its usual rate. In this district not over 60 mines were in operation, the larger part of them in Oklahoma, and at the end of the year about 50,000 tons of 60-per cent. zinc concentrates remained unsold at the mines. In Colorado about 10 per cent. of the usual output of zinc is reported as being made, and in Utah about 30 per cent. of the normal output. After the closing of the Interstate-Callahan mine at the end of October not more than 10 per cent. of the normal output of zinc was being made in Idaho. In the Butte district, Montana, many mines were closed, the output was about 28 per cent. of normal, and one-fifth of it was being stored.

ZINC ORE IMPORTED INTO THE UNITED STATES, IN SHORT TONS

Source.	1917.		1918.		1919.		1920.	
	Zinc Content.	Value.	Zinc Content.	Value.	Zinc Content.	Value.	Zinc Content.	Value.
Canada	5,155	$338,668	5,173	$319,815	3,878	$115,974	1,794	$68,286
Mexico	45,697	2,837,211	18,426	1,202,035	11,225	346,040	14,975	497,459
France	.....	.....	.....	.....	.....	.....	.....	.....
Spain	6,084	260,992	.....	.....	.....	.....	.....	.....
Italy	2,411	117,271	.....	.....	.....	.....	.....	.....
Australia	12,503	753,598	.....	.....	.....	.....	3,852	197,192
Other countries	625	66,388	1,210	52,119	1,906	67,476	1,866	74,315
	72,474	$4,374,058	24,809	$1,573,969	17,009	$529,660	22,487	$837,252

IMPORTS OF ZINC ORE AND ZINC DUST, IN SHORT TONS

	1913.	1914.	1915.	1916.	1917.	1918.	1919.	1920.
Zinc ore	31,416	31,962	158,852	344,611	188,925	63,305	43,437	58,726
Zinc content	13,497	12,132	57,669	148,147	72,474	24,809	17,009	22,487
Zinc dust	2,191	2,302	856	934	401	12	52	17

EXPORTS OF DOMESTIC ZINC ORE AND DROSS

Zinc ore	17,713	11,110	832	70	1,179	55	.....	.....
Zinc dross	28	2,526	4,167	48	13,302	15,816	5,123	2,245

Smelter Production of Zinc

The production of primary metallic zinc from domestic ores in 1920 was 450,476 short tons and from foreign ores 13,332 tons, a total of 463,808 tons. Of the output of domestic zinc in 1920 51,626 tons consisted of electrolytic zinc, as compared with 27,056 tons in 1919. In

addition to primary zinc there was an output of 21,371 tons of redistilled secondary zinc, making a total supply of distilled zinc and electrolytic zinc in 1920 of 485,179 tons, of which 80,713 tons was high-grade zinc, 33,893 tons intermediate, 59,811 tons select and brass special, and 310,762 tons prime western.

The exports of zinc made from foreign ores were 28,361 tons and those of zinc made from domestic ores were 85,898 tons, compared with exports of 16,789 and 129,508 tons respectively in 1919. The exports of domestic zinc included 11,852 tons of sheet zinc, as against 19,762 tons in 1919. The stock of zinc at smelters and in warehouses at the end of November was 71,037 tons, as against 29,892 tons on June 30, 1920, and 36,793 tons at the end of 1919. The apparent consumption of primary zinc during 1920 was 323,051 tons, compared with 323,964 tons in 1919 and 423,792 tons in 1918.

ZINC PRODUCED IN UNITED STATES(a)

(In short tons)

	1917.	1918.	1919.	1920.
Arkansas	25,660	26,753	31,437	31,481
Illinois	172,489	141,844	(b)118,340	(b)108,851
Kansas	76,048	29,149	43,942	41,044
Oklahoma	204,394	139,066	121,988	110,931
Pennsylvania	86,995	77,342	67,521	74,234
Other states	78,778	64,857	55,459	45,641
Electrolytic	25,209	38,916	27,056	51,626
Total primary	669,573	517,927	465,743	463,808
From domestic ore	584,597	492,405	452,272	450,476
From foreign ore:				
Australia	26,140	1,780	630	2,235
Canada	6,787	8,700	4,007	1,583
Chile	.....	886	751	536
Italy	2,951	113	.....	.....
Mexico	40,360	14,043	8,083	8,978
Spain	8,738	.....	.....	.....
Total foreign	84,976	25,522	13,471	13,332
Total primary	669,573	517,927	465,743	463,808
Redistilled secondary	16,835	9,918	19,748	21,371
Total	686,408	527,845	485,491	485,179
Grade A	97,707	129,344	45,377	80,713
Grade B	69,189	68,987	39,173	33,893
Grade C	148,749	98,584	140,917	59,811
Grade D	370,763	230,930	260,024	310,762
Total	686,408	527,845	485,491	485,179
Average price per lb., cents:				
Grade A	14.0	11.1	8.3	8.4
Grade B	12.7	10.7	7.7	8.3
Grade C	9.4	8.0	7.2	8.2
Grade D	9.0	7.9	7.1	8.0
All grades	10.2	9.1	7.3	8.1
Total value of output	$140,027,000	$96,009,000	$70,882,000	$78,599,000

(a) U. S. Geol. Surv. (b) Exclusive of electrolytic zinc made in Illinois.

In July sales of German zinc on the New York Metal Exchange were reported, although the records of the Bureau of Foreign and Domestic Commerce do not show that any important quantities of foreign zinc

slabs entered the country. In August there were offerings of American zinc for re-shipment from England. This zinc would enter free of duty, but fluctuations in sterling exchange rates prevented any business. The Bureau of Foreign and Domestic Commerce records such imports in a general class of "American goods returned," and hence they have not been specifically shown in the Monthly Summary. Research by the Bureau has shown, however, that considerable quantities of American zinc were returned in the last four months of the year, which accounts for the large imports item in the table below, only 15 tons of this amount being originally foreign zinc.

CONSUMPTION OF PRIMARY ZINC IN THE UNITED STATES (a)
(Short Tons)

	1914.	1915.	1916.	1917.	1918.	1919.	1920.
Supply:							
Stock, Jan. 1:							
In bonded warehouses	.....	111	32	90	32	.....	.....
At smelters	40,659	19,984	14,221	17,508	53,689	41,241	36,793
Production:							
From domestic ore	343,418	458,135	563,451	584,597	492,405	452,272	450,045
From foreign ore	9,631	31,384	104,005	84,976	25,522	13,471	13,332
Imports	880	904	684	257	35	70	8,177
Total available	394,588	510,518	682,393	687,428	571,683	507,054	508,347
Withdrawn:							
Exports, foreign, from warehouse	5,580	12,776	43,230	64,680	20,069	12,256	28,132
Exports, foreign, under drawback	4,981	255	.....	1,588	6,337	4,533	229
Exports, domestic	64,807	118,603	163,137	153,796	80,244	129,508	85,898
Stock, Dec. 31:							
In bonded warehouses	111	32	90	32	.....	.....	.....
At smelters	19,984	14,221	17,508	53,689	41,241	36,793	71,037
Total withdrawn	95,463	145,887	223,965	273,785	147,891	183,090	185,296
Apparent consumption	299,125	365,438	458,428	413,643	423,792	323,964	323,051

(a) C. E. Siebenthal and A. Stoll, U. S. Geol. Surv.

At the end of November 66,700 retorts were reported in operation out of a total of 156,693 retorts, as compared with 95,000 on June 30, 1920, and with 107,500 at the end of 1919. Advices late in December put the number of retorts expected to be in operation at the end of the year as about 52,500, or one-third of the total.

Few changes in capacity were made in 1920. The United States Zinc Co. changed one block of furnaces at Pueblo, Colo., to an oxide furnace. The same company took over the Kusa Spelter Co., at Kusa, Okla., in July. The Prime Western Spelter Co. disposed of the Iola plant in November. The American Metal Co. took over the Arkansas Zinc & Smelting Corporation. The United Zinc Smelting Corporation is adding 1208 retorts.

ZINC-SMELTING CAPACITY OF THE UNITED STATES[1]
(Number of Retorts at End of Years)

Name.	Situation.	1917.	1918.	1919.
American Spelter Co.	Pittsburg, Kan.	896	(h) 896	(h) 896
American Steel & Wire Co.	Donora, Penn.	9,120	9,120	8,208
American Zinc and Chem. Co.	Langeloth, Penn.	7,296	7,296	7,296
American Zinc Co. of Ill.	Hillsboro, Ill.	4,864	4,864	4,864
American Zinc, Lead and Smg. Co.	Dearing, Kan.	4,480	(g)	.....
American Zinc, Lead and Smg. Co.	Caney, Kan.	6,080	(n) 6,080	(n) 6,080
American Zinc, Lead and Smg. Co. (c)	Neodesha, Kan.	3,760	(g)	.....
American Zinc, Lead and Smg. Co. (c)	E. St. Louis, Ill.	5,620	5,620	5,620
Arkansas Zinc, Lead and Smg. Corpn.	Van Buren, Ark.	3,200	3,200	3,200
Athletic Min. and Smelting Co.	Fort Smith, Ark.	1,664	2,496	2,496
Bartlesville Zinc Co.	Bartlesville, Okla.	5,184	7,488	5,184
Bartlesville Zinc Co.	Blackwell, Okla.	9,600	9,600	9,600
Bartlesville Zinc Co.	Collinsville, Okla.	13,440	(g)	.....
Bartlesville Zinc Co., Lanyon-Starr Branch	Bartlesville, Okla.	3,456	3,456	3,456
Collinsville Zinc Co.	Collinsville, Ill.	1,984	.....	.....
Eagle-Picher Lead Co.	Henryetta, Okla.	3,000	4,000	4,000
Eagle-Picher Lead Co. (e)	Hillsboro, Ill.	3,200	3,200	3,200
Edgar Zinc Co.	Carondelet, Mo.	1,982	(g)	.....
Edgar Zinc Co.	Cherryvale, Kan.	5,040	5,040	4,984
Fort Smith Spelter Co.	Fort Smith, Ark.	2,560	2,560	2,560
Grasselli Chemical Co.	Clarksburg, W. Va.	5,760	5,760	5,760
Grasselli Chemical Co.	Meadowbrook, W. Va.	8,520	8,520	8,400
Grasselli Chemical Co.	Terre Haute, Ind.	3,360	4,200	4,200
Hegeler Zinc Co.	Danville, Ill.	5,400	5,400	5,400
Henryetta Spelter Co.	Henryetta, Okla.	(a) 3,000	.....	.....
Illinois Zinc Co.	Peru, Ill.	4,640	5,440	5,520
J. B. Kirk Gas and Acid Co.	Iola, Kan.	3,440	.....	.....
Kusa Spelter Co.	Kusa, Okla.	7,520	5,360	5,360
Lanyon Smelting Co.	Pittsburg, Kan.	(h) 448	(h) 448	(h) 448
Mathiessen & Hegeler Zinc Co.	La Salle, Ill.	6,168	6,168	6,132
Mineral Point Zinc Co.	Depue, Ill.	9,068	9,068	9,068
National Zinc Co.	Bartlesville, Okla.	4,256	4,160	4,256
National Zinc Co.	Springfield, Ill	4,480	4,480	4,480
New Jersey Zinc Co. of Penn.	Palmerton, Penn.	7,200	7,200	7,192
Newkirk Smelter Co.	Newkirk, Okla.	(g)	(b)	.....
Oklahoma Spelter Co.	Kusa, Okla.	(h) 1,600	(h) 1,600	(h) 1,600
Owen Spelter Co.	Caney, Kan.	1,920	(h) 1,920	(d) .....
Pittsburg Zinc Co.	Pittsburg, Kan.	(h) 910	(h) 910	(j) .....
Prime Western Spelter Co. (o)	Iola, Kan.	4,866	1,972	2,320
Quinton Spelter Co.	Quinton, Okla.	2,016	2,016	2,016
Sandoval Zinc Co.	Sandoval, Ill.	672	672	336
Tulsa Fuel and Manufacturing Co.	Collinsville, Okla.	6,232	6,232	6,232
United States Smelting Co.	Altoona, Kan.	4,640	(g)	.....
United States Smelting Co.	Checotah, Okla.	5,120	5,120	5,120
United States Zinc Co. (l)	Henryetta, Okla.	2,400	3,448	3,448
United States Zinc Co.	Sand Springs, Okla.	8,000	7,560	6,680
United States Zinc Co.	Pueblo, Colo.	2,200	2,208	2,208
United Zinc Smelting Corpn.	Moundsville, W. Va.	(m) 1,728	1,728	1,728
United Zinc Smelting Corpn (i). (a)	Clarksburg, W. Va.	3,648	(a) 3,648	3,648
Weir Smelting Co.	Weir, Kan.	(a) 448	(h) 448	(h) 448
Weir Smelting Co.	Caney, Kan.	(d)	(d)	1,280
Totals		216,046	180,602	174,924

(a) Closed during latter part of 1918 and all of 1919. (b) No report received. (c) Formerly Granby Mining and Smelting Co. (d) Taken over by Weir Smelting Co. in 1919. (e) Plant of Robert Lanyon Zinc and Acid Co. taken over by Eagle-Picher Co. in July, 1919. (g) Dismantled. (h) Idle all year. (i) Formerly Clarksburg Zinc Co. (j) Purchased by Newkirk Smelter Co. in 1919 and moved to Oklahoma. (k) Absorbed by Kusa Spelter Co. (l) Formerly Western Spelter Co. (m) Not yet in operation. (n) Part (4 blocks) leased to Weir Smelting Co. (o) Plant at Gas City, Kan., wrecked by cyclone, March, 1918.

Discussing the situation in the United States the *Engineering and Mining Journal* of Mar. 26, 1921, says:

In the United States little zinc is being consumed compared with the normal demand, so that with the great decrease in production any sudden increase in consuming demand would probably be difficult to meet with domestic supplies alone. Zinc is in a good statistical position and should be one of the first metals to recover. Stocks on hand at the beginning of 1921 are estimated by the U. S. Geological Survey

[1] *Eng. Min. Jour.*

at about 71,000 tons, or more than two months' consumption based upon the 1920 record. The present low production should be of material assistance in making inroads in this surplus.

It is out of the question for the domestic market to rise under the influence that European zinc conditions now exert over the world's market. Although the United States produces the greatest proportion of the world's zinc, prices are controlled by minority outputs.

American producers seeking a higher tariff as a solution to their difficulties should not lose sight of the fact that the tariff alone is not a complete cure, as their own industry is linked closely to the general prosperity in this country, to the steel trade, paint trade, building construction, and other activities no one of which is in a happy or satisfactory position.

Zinc Dust.—The production of zinc dust in the United States shows a gradual increase from 1910 to 1919, with a large increase in 1920, and is given in the table.[1]

	Tons.		Tons.
1910	69	1916	2,609
1911	254	1917	5,913
1912	492	1918	6,995
1913	423	1919	6,598
1914	1,004	1920	11,339
1915	1,755		

Production of Rolled Zinc in 1920.—The production of rolled zinc in the United States in 1920 declined about 2 per cent. in quantity but increased 7 per cent. in value as compared with that in 1919. The loss in quantity was greatest in boiler plates and heavy sheets, amounting to 22 per cent., and there was also a loss in the quantity of zinc strips, but a slight gain in ordinary zinc sheets.

The output of the different forms of rolled zinc during 1920, according to statistics compiled by the United States Geological Survey, is given in the table below, which also includes the exports as shown by the records of the Bureau of Foreign and Domestic Commerce. If the figures showing the exports are deducted from those showing the production the result will approximate the domestic consumption.

The following tables give the *Engineering and Mining Journal* figures for zinc production of ore smelters, including the output by quarters:

ZINC PRODUCTION, 1916–1920, BY QUARTERS
(In Tons of 2000 Pounds)
Reports of Ore Smelters Only

District. 1916.	I.	II.	III.	IV.
Illinois	45,344	45,547	41,953	48,651
Arkansas	.....	.....	2,977	4,660
Kansas-Missouri	38,513	42,488	39,447	33,948
Oklahoma	34,994	38,786	42,604	52,680
Others (a)	37,853	39,873	41,514	48,186
Totals	156,704	166,694	168,495	188,125

[1] *Eng. Min. Jour.*

Districts.	I.	II.	III.	IV.
1917.				
Illinois	48,756	47,237	40,379	39,699
Arkansas	5,597	6,847	7,596	5,661
Kansas-Missouri	26,350	25,621	19,443	15,091
Oklahoma	53,280	57,227	48,478	45,602
Electrolytic	7,950	8,362	5,096	5,837
Others (a)	42,013	41,700	39,736	38,853
Totals	183,946	186,994	160,728	150,743
1918.				
Illinois	34,848	34,829	36,445	35,686
Arkansas	6,156	5,603	7,618	7,373
Kansas-Missouri	10,284	5,016	7,198	9,336
Oklahoma	37,751	35,261	35,036	35,323
Electrolytic	8,094	9,407	11,049	10,335
Others (a)	36,881	36,265	35,481	34,075
Totals	134,014	126,381	132,827	132,128
1919.				
Illinois	34,018	27,694	29,344	27,575
Arkansas	7,622	7,082	8,196	8,496
Kansas-Missouri	11,303	10,819	10,617	10,608
Oklahoma	36,142	27,484	25,829	29,999
Electrolytic	10,446	12,370	3,146	.....
Others (a)	37,024	36,050	30,467	29,353
Totals	136,555	121,499	107,599	106,031
1920.				
Illinois	31,551	31,406	24,949	21,577
Arkansas	7,900	7,500	9,000	5,566
Kansas-Missouri	7,389	6,432	6,749	4,561
Oklahoma	27,971	25,283	22,105	22,331
Electrolytic	11,659	15,208	17,098	13,476
Others (a)	46,014	44,233	36,945	32,869
Totals	132,484	130,062	116,846	100,380

Through the courtesy of the American Zinc Institute, the 1920 figures have been compared with the summary of the Institute.

(a) With the exception of one plant in Colorado these are all Eastern works. In the fourth quarter of 1915 and 1916 is included Anaconda and other electrolytic production.

PRODUCTION OF ZINC
(In Tons of 2000 Lb.)
By Ore Smelters Only

States.	1915.	1916.	1917.	1918.	1919.	1920.
Arkansas	.....	7,637	25,701	26,750	31,396	29,966
Colorado	8,984	8,908	7,735	3,897	2,779	1,682
Illinois	161,665	181,495	176,071	141,808	118,631	109,483
Missouri-Kansas	111,052	154,396	86,505	31,834	43,347	25,131
Oklahoma	111,405	169,064	204,587	143,371	119,454	97,690
Electrolytic	.....	10,963	27,245	38,885	25,962	57,441
East and others (a)	114,036	147,555	154,567	138,805	130,115	158,379
Totals	507,142	680,018	682,411	525,350	471,684	479,772

(a) Includes Anaconda and other electrolytic production in 1915.

Rolled zinc is quoted at so much a pound, with discounts and extras for different gages and special sizes and shapes. At the beginning of 1920 zinc sheets were quoted at 11.5 cts. a lb. in 100-lb. lots, with 8 per cent. discount in carload lots. Zinc plates were on a basis of 10.5 cts. On

Jan. 6 the price of zinc sheets was advanced to 12 cts., and on Jan. 15 to 12.5 cts. The basic quotation remained at 12.5 cts. a lb. until Nov. 8, when it was reduced to 11.5 cts. and plates to 10.5 cts., and there was no further change during the year.

Both the quantity and the value by classes of product given in the accompanying table are subject to slight correction, because some producers who sell from a single base price do not separate their sales according to classes of product (which are arbitrary anyhow) and were to that extent obliged to make estimates; others, who themselves use the greater part of their output, had to estimate values. But the total production and value and the average price given may be considered accurate. The average selling price for 1920 agrees closely with the average price shown by the exporters' manifests, although there was a considerable difference in 1919.

ZINC ROLLED IN THE UNITED STATES (a)

	1919.	1920.
Zinc sheets:		
Quantity (pounds)	56,514,868	56,812,989
Value	$6,023,773	$6,625,660
Boiler plates and special sheets:		
Quantity (pounds)	5,083,137	3,950,489
Value	$521,389	$402,035
Zinc strips:		
Quantity (pounds)	46,995,742	45,704,052
Value	$4,902,407	$5,262,538
Total rolled zinc (pounds)	108,593,747	106,467,530
Total value	$11,447,569	$12,290,233
Rolled zinc exported:		
Quantity (pounds)	39,524,516	23,704,197
Value	$5,212,002	$2,832,993
Available for consumption (pounds)	69,069,231	82,763,333

(a) Compiled by C. E. Siebenthal and A. Stoll, U. S. Geol. Surv.

Zinc Market in 1920

The average quotation for prime-western zinc at St. Louis in 1920 was 7.8 cts. a lb., compared with 7 cts. in 1919 and 8 cts. in 1918. The price of prime-western zinc began the year at 9.05 cts. in the St. Louis market, rose to 9.375 cts. on Jan. 12, declined to 7.35 cts. on June 18, rose to 8.15 cts. on Aug. 24, and then dropped sharply to 5.625 cts. on Nov. 30. A short rise carried the price up to 6.25 cts. on Dec. 6, but it declined again and finished the year at about 5.5 cts. The decline in the last quarter of the year was coincident with offerings of foreign zinc at New York at prices below the current domestic quotations. No important quantity of such zinc had entered the country prior to Nov. 30, but considerable purchases are reported to have been made in December.

MONTHLY AVERAGE PRICE OF ZINC SLABS (a)

	St. Louis.				London.			
	1917.	1918.	1919.	1920.	1917.	1918.	1919.	1920.
January	9.449	7.661	6.922	9.133	48.329	54.000	56.045	58.643
February	9.875	7.639	6.273	8.708	47.000	54.000	46.150	61.338
March	10.130	7.286	6.150	8.531	47.000	54.000	38.500	53.467
April	9.289	6.715	6.114	8.184	54.632	54.000	36.188	47.388
May	9.192	7.114	6.079	7.588	54.000	54.000	35.477	45.088
June	9.201	7.791	6.551	7.465	54.000	54.000	36.763	41.193
July	8.473	8.338	7.523	7.720	54.000	54.000	41.815	41.886
August	8.190	8.635	7.439	7.835	54.000	54.000	39.338	41.220
September	7.966	9.092	7.160	7.661	54.000	54.000	40.955	39.690
October	7.813	8.451	7.473	7.150	54.000	54.000	43.630	39.756
November	7.672	8.141	7.827	6.247	54.000	54.100	46.588	35.028
December	7.510	7.813	8.350	5.824	54.000	56.050	53.101	27.762
Year	8.730	7.890	6.988	7.671	52.413	54.180	42.879	44.372

St. Louis, cents per pound. London, pounds sterling per long ton.
(a) *Eng. Min. Jour.*

AVERAGE PRICE OF ZINC SHEETS
(In Cents per Pound)

	1917.	1918.	1919.	1920.		1917.	1918.	1919.	1920.		1917.	1918.	1919.	1920.
Jan	21.00	19.00	13.00	12.20	May	19.00	15.00	10.00	12.50	Sept	19.00	15.00	10.50	12.50
Feb	21.00	18.00	11.36	12.50	June	19.00	15.00	10.00	12.50	Oct	19.00	15.00	10.50	12.50
Mar	21.00	15.00	10.40	12.50	July	19.00	15.00	10.40	12.50	Nov	19.00	15.00	10.78	11.67
April	20.44	15.00	10.00	12.50	Aug	19.00	15.00	10.50	12.50	Dec	19.00	15.00	11.15	11.50

Average for the year 1917—19.62 cents, 1918—15.58 cents, 1919—10.72. cents, 1920—12.33 cents
NOTE.—These are base prices for ordinary size sheets, in carload lots, f.o.b. LaSalle-Peru, Ill., less 8 per cent. discount.

SECONDARY ZINC[1]

The output of secondary zinc (including that in brass) in 1920 amounted to 115,500 tons, and equaled 23.8 per cent. of the output of primary zinc in the United States in 1920, nearly the same percentage as in 1918 and 1919. The recovery was 7046 tons more than in 1919 but 5140 tons less than in 1918.

One smelter in New Jersey, one in New York, and one in California, which treat only zinc drosses and skimmings, use large graphite retorts of 600 to 800 lb. capacity instead of the small clay retorts used by smelters treating ore or mixed ore and drosses. The many uses of zinc drosses and skimmings create active competition for their purchase. Considerable zinc is recovered by sweating, and the residues are sold for redistillation. Secondary zinc varies in quality, just as the zinc derived from ore does, but a part of the secondary zinc is reported to be of excellent quality.

Two plants in San Francisco are making zinc dust from zinc dross, so that all that material has a good market; but none of the secondary plants on the Pacific Coast treat zinc ashes or skimmings, and it is neces-

[1] J. P. Dunlop, U. S. Geol. Surv.

sary to ship them to eastern plants for treatment. The high-grade zinc dust is used at domestic and foreign gold and silver mines to precipitate the metals from cyanide solutions.

SECONDARY ZINC RECOVERED, 1919

	Short Tons.
Zinc recovered by redistillation:	
By plants that also treat ores	10,767
By plants that treat only secondary material	8,981
Total redistilled	19,748
Zinc recovered by remelting, sweating, etc.	20,162
Total zinc recovered unalloyed	39,910
Zinc recovered in alloys other than brass	6,062
Zinc recovered in brass (estimated)	62,432
Zinc chloride made in 1919, of which 26,250 tons was made from zinc ashes, skimmings, etc.	41,500
Zinc content of skimmings and ashes, recovered in chloride	6,500
Lithopone made in 1919, of which 53,000 tons was made from zinc ashes, etc.	79,619
Zinc content of zinc ashes and skimmings recovered in lithopone	10,600

SECONDARY ZINC RECOVERED, 1920

	Short Tons.
Zinc recovered by redistillation	21,371
Zinc recovered by remelting, sweating, etc.	21,479
Total zinc recovered unalloyed	42,850
Zinc recovered in alloys other than brass	7,650
Zinc recovered in brass (estimated)	65,000
Zinc dust made from zinc dross	1,179
Estimated quantity of zinc dross used for dust	1,400

ZINC PIGMENTS MARKETED IN THE UNITED STATES (a) (In Short Tons)

Pigment.	1918.		1919.		1920.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Zinc oxide	100,286	$20,560,247	117,639	$20,591,877	99,444	$17,859,736
Leaded zinc oxide	26,714	4,480,565	27,591	4,009,024	30,460	4,467,532
Lithopone	62,403	7,923,276	79,619	10,111,210	89,373	12,484,924
	189,403	32,964,088	224,849	34,712,111	219,277	34,816,193

(a) U. S. Geol. Surv.

Zinc Mining in the United States

Arizona.[1]—The output of recoverable zinc decreased from 1,717,000 lb. in 1919 to about 1,457,000 lb. in 1920. The value decreased from $125,341 to about $118,000. The Arizona Hillside Mining Co., in Yavapai County, was the only large producer, and this mine was closed late in the year.

Arkansas.[2]—Industrial conditions following the war had a depressing effect upon mining in Arkansas in 1920. In the mining of zinc there has been a decided slump, from which it is feared a return to former prosperity will not take place until there has been an advance in prices.

California.—In the Shasta region the Bully Hill Copper Mining &

[1] U. S. Geol. Surv.
[2] J. G. Ferguson, Commissioner of Mines, Manufactures and Agriculture, Little Rock, Ark., *Eng. Min. Jour.*

Smelting Co.'s group of mines was taken over by Hayden Stone & Co. and the Shasta Zinc & Copper Co. formed with D. C. Jackling as managing director. A zinc-oxide plant and reverberatory are under construction, and operations are expected to begin in March, 1921. The Balaklala smelter was torn down, and the steel will be used in the construction of the new plant at Bully Hill. At the Mammoth mine of the U. S. Smelting, Refining & Mining Co. operations were restricted to development during 1920, 100 men being employed.[1]

The zinc output of California in 1920 is estimated at 1,165,509 lb. or 692,519 lb. more than in 1919. Zinc was produced at only a few mines in the State, all in Inyo County.[2]

Colorado.—Despite curtailment of operations in November and December in many mining districts of Colorado, the production in the State in 1920, according to Charles W. Henderson, of the U. S. Geological Survey, was 45,566,613 lb. of zinc, as compared with 38,112,424 lb. of zinc in 1919.

The increase in the zinc production over that of 1919 can be attributed in part to the fact that the Sunnyside Co.'s new 500-ton concentration-flotation mill at Eureka, San Juan County, began operations early in 1920 and continued operations steadily throughout the year, producing both lead and zinc concentrate. The Wellington mine at Breckenridge also increased its output in 1920.

The zinc-oxide plant at Leadville continued operations on low-grade zinc-carbonate ores. As a result of reorganization assuring a steady supply of zinc-carbonate ores from the Downtown mines, a new block of furnaces was completed in August, but the new block was not placed in operation because of the waning market for zinc oxide. The Ohio zinc-oxide plant at Canon City was operated until early in December on zinc-carbonate ores from Leadville and from camps in Utah and Nevada. The Empire Zinc Co. constructed and set in operation as a trial a very modern zinc-oxide plant at Canon City, where is situated also that company's magnetic-separation plant, which has been successfully operated for many years on Leadville zinc-sulphide ores. The River Smelting & Refining Co.'s plant at Florence for the treatment of low-grade copper-lead-zinc ores by the matting and fuming process was operated until December. Breckenridge, with its zinc-sulphide ores increased its output of zinc 100 per cent.

Much development work was done on the zinc deposits at Red Cliff, and zinc-sulphide milling ore was shipped from this camp to Canon City and pyritic silver ore to the lead smelter at Leadville.

San Juan County showed a very large increase in metal output.

[1] *Eng. Min. Jour.* [2] U. S. Geol. Surv.

The Sunnyside Co., at Eureka, after a long building program and many setbacks by fire and snow-slides, began milling early in 1920 a large quantity of mixed lead-zinc ores. The Iowa-Tiger mine, at Silverton, continued production until December under lease.

Idaho.[1]—The mine output of recoverable zinc in Idaho increased from 15,994,229 lb. in 1919 to about 27,932,000 lb. in 1920. The price of zinc was higher, and the Consolidated Interstate-Callahan mine, at Sunset, was active during most of the year. In November, however, shipments from this mine ceased, as the market for western zinc ore was poor. Large shipments of zinc concentrate were also made by the Morning mine of the Federal Mining & Smelting Co.

Illinois.[2]—The production of zinc in Illinois shows a decrease in 1920. The average price of zinc concentrate was about $1 less for most of the year than in 1919. In November and December the depression in prices became acute. Only two mines of any size are operating in Illinois.

Montana.[3]—The output of recoverable zinc in Montana increased from 168,763,823 lb. in 1919 to about 184,338,000 lb. in 1920, which was close to the record of 1918. The value of the output increased from $12,319,759 to about $14,931,360. The principal producers of zinc in Montana were the Butte & Superior, Elm Orlu, the zinc mines of the Anaconda Co., and the Emma mine. The Snow Storm mine, in Lincoln County, and the Montana Consolidated, in Jefferson County, each made a small output. Much of the zinc concentrate has been smelted in the East, but during 1920 a greater quantity was leached at Great Falls. Owing to the increased price of zinc the management of the electrolytic plant treated a much greater quantity of concentrates than was treated in 1919.

Operations at the Black Rock mine of the Butte & Superior company were curtailed to about two-thirds of normal capacity, but the usual grade of zinc ore was mined throughout 1920. New development work extended to the 2300 level, and the shaft is now being sunk to the 2600. The Elm Orlu Mining Co. operated its Elm Orlu mine at the rate of 750 tons per day, or about 75 per cent. of normal, throughout 1920. Work was done on all deeper levels to the 2600. The ore was largely zinc, but some copper was mined, all of which was treated at the Timber Butte mill.[4]

Nevada.[5]—The mine output of recoverable zinc increased slightly in quantity from 10,698,900 lb. in 1919 to about 10,698,000 lb. in 1920, and in value from $657,343 to about $866,541. In 1920, as in past years, most

[1] U. S. Geol. Surv.
[2] *Eng. Min. Jour.*
[3] U. S. Geol. Surv.
[4] *Eng. Min. Jour.*
[5] U. S. Geol. Surv.

of the output was made in the Yellow Pine district, in Clark County, where the Yellow Pine mine is the largest producer. The Consolidated Coppermines, in White Pine County, made large shipments of zinc ore, but the output was only about half that of 1919. The average price of zinc for the year was more than 8 cts. per lb., but in November and December the price dropped and the Yellow Pine mine was closed.

New Jersey.[1]—The production of zinc ore in New Jersey in 1920 was 12 to 15 per cent. less than in 1919, and during the latter part of the year the mines were run on part time.

New Mexico.[2]—The output of zinc-sulphide and zinc-carbonate ores increased in 1920. Carbonate ores only were shipped from the Kelly mine, at Kelly, but the Ozark Co.'s mill at Kelly produced a considerable quantity of zinc concentrates and lead-zinc sulphide and carbonate, and zinc-carbonate ores were shipped direct to smelters from the Ozark Co.'s mine. Some zinc-carbonate ore was shipped from the Hanover mine, at Hanover, and a considerable quantity of concentrate obtained from the treatment of sulphide ores from the Hanover and Republic mines was shipped from the Hanover concentrating plant. The Grubnau zinc-oxide plant, built in 1917 at Waldo, Santa Fe County, continued operations in 1920 on New Mexico zinc-carbonate ores.

The Calumet-New Mexico operated a 60-ton mill until the zinc market dropped, but after a limited shutdown milling was resumed on custom ores from the surrounding district.

Utah.[3]—There was an increase of about 84 per cent. in the production of recoverable zinc. The mine output increased from 4,431,024 lb. in 1919 to about 8,157,700 lb. in 1920, and the value of the output increased from $323,465 to about $660,777. The principal producers of zinc were the Daly Judge, United States Mining Co., Scranton, and the Utah Apex Mining Co. The electrolytic plant of the Judge Mining & Smelting Co., at Park City, was active most of the year, treating zinc concentrate from its own property. The average price of zinc was higher than during 1919, but in general production was retarded by the continued high costs of mining, milling, smelting, and refining, and in August the increased freight-rate on ore and bullion added another handicap to mining.

Washington.[3]—Several hundred tons of zinc ore was shipped from the Northport district in 1920. No large output of zinc ore has been made since 1917, when the Last Chance mine was operated. The State's output of recoverable zinc amounted to 426,496 lb. in 1920.

Wisconsin.[3]—The tonnage of zinc ore shipped in 1920 from the Wisconsin districts decreased 35 per cent. from that of 1919, as shown

[1] *Eng. Min. Jour.*
[2] U. S. Geol. Surv.
[3] J. E. Kennedy, *Eng. Min. Jour.*

in the table. The gross tonnage of zinc ore shipped from mines to smelteries without and to separating plants within the district decreased 25 per cent.

Market conditions were unstable throughout 1920. The margin between premium and prime-western grades of blende, both bought on a basis of 60 per cent. zinc, was practically eliminated. Buyers of the higher grade, formerly well represented in purchases, made little or no effort to buy. A larger percentage of the tonnage was sold under contracts, and weekly open-market quotations were not always obtainable. The base price for January was $60 to $61 per ton, and this was the highest level attained throughout the year, the average base approximating $50, with the year-end price at $40 and lower.

WISCONSIN ZINC-ORE SHIPMENTS
(Short Tons)

	Net to Smelteries, Tons.			Gross from Mines, Tons.		
	1918.	1919.	1920.	1918.	1919.	1920.
Highland	8,049	8,112	2,551	8,049	8,112	2,551
Linden	76	56	50	5,628	865	1,869
Mifflin	1,242	89	316	31,152	20,874	29,405
Mineral Point	35,034	29,097	25,592	368	.....	.....
Platteville	2,913	1,859	1,887	3,335	1,993	1,887
Dodgeville	260	.....	.....	1,651	190	.....
Cuba City	21,038	24,581	18,289	1,880	6,887	11,278
Benton-New Diggings	48,449	33,439	14,372	105,286	82,516	50,501
Hazel Green	.....	80	.....	6,234	9,836	4,467
Shullsburg	3,388	2,742	.....	11,887	8,585	3,024
Galena (Ill.)	405	80	.....	13,424	24,873	17,966
Totals	120,854	100,135	63,057(a)	189,058	164,731	122,948(a)

(a) Totals to Dec. 11, 1920.

A total of thirty-two concentrating mills and five separating plants operated at various times during 1920, as against forty-two mills and five separating plants in 1919. High labor and material costs stimulated effort toward increased efficiency. The U. S. Bureau of Mines established a substation at the Wisconsin State Mining School, at Platteville, to carry on research and experimental work. A change in milling practice initiated in 1920 by D. I. Hayers, of the Wisconsin Zinc Co., reduced tailings losses. Little new construction and development work was undertaken. The Vinegar Hill Zinc Co. completed its mill on the Fields-Meloy property. The Wisconsin Zinc Co. moved one of its milling plants to the east end of the Champion tract, where it utilized the Blackstone shaft. The Connecting Link Co. completed its No. 1 mill. A Chicago company was sinking a shaft and completing a mill on the Nightingale lease at Benton at the year end. The Mineral Point Zinc Co. wrecked its last mill at Highland, which fact indicates the apparent depletion of practically the only remaining zinc-carbonate deposits of this

district. The National Zinc Ore Separating Co. purchased and completed the Government's partly finished acid plant at Cuba City, making a high-grade sulphuric acid.

Joplin-Miami District.[1]—Shipment of blende from the zinc-lead mines of Oklahoma, Kansas, and Missouri in 1920 exceeded 500,000 short tons, an excess over 1919 of 90,000 tons. Oklahoma gained 52,280 tons of blende, Kansas gained 49,320 tons, Missouri lost 15,050 tons of blende and 1,930 tons of calamine. The year was wholly unparalleled in production of zinc and lead, and the value returns are the greatest recorded. Oklahoma zinc shipments were lightest during the last half-year, Kansas loaded heaviest in the last half-year, and Missouri slowed down during the last half.

The Oklahoma-Kansas group of mines extends north and northeast from the point of origin, four miles north of Miami, Okla., the northward trend passing into Kansas north of Picher. The northeast swing of operations has made no alignment of contiguous development, but produced several splendid mines, with intervening undeveloped territory, leading toward the Chanute Spelter Co.'s great Hartley mine in Kansas. The older Oklahoma mines in the vicinity of Lincolnville, nearly due south of the Hartley mine, made some progress during the year.

Discovery a few years ago of a mine of promise west of Waco, Mo., has, with subsequent development, enlarged the Waco area well across the state line in Kansas, until there are several mines producing zinc blende fron an ore-level as richly mineralized with zinc as the Picher area, but lean in lead, yielding a splendid zinc for rolled-zinc products. The increase in 1920 of the Waco area was from the Kansas side of the Missouri-Kansas state line, with development on the Missouri side neglected. The older Missouri mines producing blende, aside from Oronogo, are a negligible quantity as regards output and the calamine mines are making a lower record each succeeding year.

SHIPMENTS OF ZINC BLENDE AND CALAMINE IN THE JOPLIN DISTRICT, 1920

	Blende, Pounds.	Calamine, Pounds.
Oklahoma—Ottawa County	792,688,810	.....
Kansas—Cherokee County	254,126,970	.....
Missouri—Jasper County	76,523,580	1,790,750
Newton County	2,369,680	16,481,540
Lawrence County	1,944,030	1,146,900
Other counties (a)	451,720	243,110
Missouri totals	81,289,010	19,662,300
1920 District totals	1,128,104,790	19,662,300
1919 District totals	937,745,880	23,516,360
Increase	190,354,910	.....
Decrease	.....	3,854,060

(a) Includes ores brought by Joplin purchasing agencies in Greene, Barry, Ozark, Wright and Howel counties. Two cars each of blende and calamine from Arkansas are not included.

[1] Jesse A. Zook, *Eng. Min. Jour.*

MONTHLY AVERAGE PRICES OF BLENDE AND CALAMINE IN THE JOPLIN DISTRICT
(Per Ton of 2000 Lb.)

	Blende.			Calamine.			All Zinc Ores.		
	1918.	1919.	1920.	1918.	1919.	1920.	1918.	1919.	1920.
January	$56.01	$43.25	$53.90	$35.97	$35.28	$31.02	$55.14	$43.08	$53.35
February	55.84	41.02	51.82	37.46	32.28	36.00	54.99	41.03	50.69
March	54.40	41.82	52.15	38.08	31.04	36.75	53.72	41.70	51.27
April	47.56	38.85	51.22	32.82	26.26	38.20	46.96	38.37	51.11
May	44.59	36.44	46.45	31.89	23.03	37.98	44.16	36.10	46.34
June	49.61	39.79	47.04	34.53	24.47	37.17	48.78	39.69	46.90
July	52.52	47.39	43.47	35.66	28.88	35 59	51.89	46.75	43.33
August	55.75	48.73	45.99	36.66	30.73	38.35	54.83	48.30	45.64
September	53.26	44.75	46.55	37.91	28.63	37.42	52.73	44.06	45.12
October	53.80	44.33	44.89	37.91	33.44	36.93	52.95	43.78	44.53
November	53.29	45.94	44.66	39.62	33.31	38.13	51.97	45.77	44.52
December	44.16	48.55	36.95	36.00	35.63	35.41	44.00	48.35	35.00
Year	$52.00	$43.40	$47.01	$37.14	$30.24	$36.11	$51.33	$43.08	$46.49

ORE PRICES IN JOPLIN DISTRICT
(Per Short Ton)

Year.	Zinc Ore.	
	High.	Average.
1906	$54.00	$43.30
1907	53.50	43.68
1908	47.00	34.36
1909	55.00	41.08
1910	52.00	40.42
1911	51.00	39.90
1912	67.00	53.33
1913	59.00	42.26
1914	54.00	40.46
1915	138.90	79.30
1916	131.70	84.72
1917	101.95	67.70
1918	78.70	51.33
1919	57.60	43.08
1920	61.50	46.49

The large reserve stock in the bins at the end of 1919, from lack of transportation facilities, was carried on advance buying throughout three-fourths of 1920, as shippers could obtain few cars except on a showing of tonnage purchased. Box-cars were unobtainable, and shipments were made in cattle and coal cars. Following the initiation of increased freight-rates, cars began arriving, until at the close of November a mile of empty cars were reported on side tracks in the three mining counties.

Prime-western grades of zinc blende opened 1920 at $57.50 @$55, holding through January, closing February at $52.50, March at $47.50, then opening April at $50 and closing at $45, the price varying from $45 down to $42.50, until the end of June, when $45 was resumed, up to $47.50 through July and August, receding to $45 the end of September, and from here declining to $30 with the advent of December. Premium grades generally were $1 higher and fines $2.50 and slimes $5 lower all of the year.

Zinc calamine established a new price record, the strong demand bringing a price-level far above a generally conceded parity with blende. Only by maintaining a high basis was there a possibility of continuing

production sufficient to meet the unusual demand. The basis price was $35 and $36 for 10 months, showing the first weakness in November, receding to no demand at the end of the year.

Zinc blende was $27.50 per ton lower at the close than at the opening of 1920.

The following record of two 4-year periods, the former of pre-war and the latter during and following, illustrates compactly the demand war placed upon this district in the weekly production of zinc.

Year.	Zinc, Tons.	Year.	Zinc, Tons.
1913	5,328	1917	8,500
1914	3,950	1918	9,080
1915	5,728	1919	9,258
1916	6,767	1920	10,835
Average	5,442	Average	9,418

The opening of 1921 indicates a reversal to pre-war demand, with an average weekly production of 5600 tons shown to the end of April.

MINE PRODUCTION OF ZINC IN THE UNITED STATES (a)
(In short tons)

	Recoverable Zinc Content of Ore Shipped.					
	1918.		1919.		1920.	
Arkansas		951		189		329
Arizona		1,135		859		700
California		2,781		236		550
Colorado		44,567		25,723		25,000
Idaho		22,581		7,997		14,000
Kentucky		315		36		9
Joplin district: Kansas	30,197		47,636		61,069	
Joplin district: Oklahoma	161,401		178,410		219,188	
Joplin district: S. W. Missouri	55,918	247,516	31,468	257,514	24,422	305,000
Central and S. E. Missouri		74		72		19
Montana		104,629		84,382		102,000
Nevada		8,362		4,502		4,500
New Hampshire		14				
New Jersey		98,470		92,912		77,371
New Mexico		12,025		3,797		5,300
New York		3,776		5,120		5,654
Tennessee		21,071		23,747		19,217
Utah		9,200		2,216		3,000
Virginia		951				
Washington		19		.....		204
Wisconsin district: Wisconsin	50,014		40,765		27,286	
Wisconsin district: Illinois	3,792	53,806	6,788	47,553	4,720	32,006
Total		632,243		556,855		595,000

(a) U. S. Geol. Surv.

Foreign Zinc Industry in 1920

Of the European zinc-producing centers Belgium and Upper Silesia seem to be in the best condition. Belgium started the year with a smelter output of about 4500 short tons monthly, which it brought up by the middle of the year to about 8000 tons. After that the output remained about stationary, so that the total production for the year was probably about 90,000 short tons. Reports near the end of the year indi-

cate that the output is slackening and considerable stocks are on hand. The total stocks in Europe are thought to amount to 100,000 short tons. Belgian smelters have recently contracted for a supply of Australian zinc concentrates. The zinc output of smelters in Upper Silesia in 1919 was 81,596 short tons, equal to about 60 per cent. of the production in 1918. Reports for the first half of 1920 indicate a little larger production than in 1919, the output for the six months being 49,643 short tons. The zinc industry in other European countries and in Japan is reported at a low ebb. Perhaps the most noteworthy happening in the zinc industry during the year was the acquisition of the Mount Read and Roseberry mines, Tasmania, by the Electrolytic Zinc Co. of Australasia, by which that company gains immense reserves of ore. The enlargement of the electrolytic zinc plant at Risdon, near Hobart, Tasmania, continues, a zinc rolling mill and a zinc-oxide plant having been installed.

The European correspondent of the American Zinc Institute, according to *Metal Bulletin*, London, Dec. 9, 1920, in dealing with the situation of the zinc industry in Europe finds that zinc smelting in Great Britain is practically suspended, and that spelter cannot be produced under £50 a ton. There are still around 20,000 tons of government stocks of spelter here, a mere trifle if the demand was on a pre-war scale.

The drop in the price of spelter hit the Belgian producers badly, with a stock of unsold slab and zinc sheets exceeding 30,000 tons.

In France very few smelters are in operation, prices of coal and coke being a stumbling block to economic smelting.

German smelters, with the advantage of exchange and the low value of the mark in their favor, are drawing ore from Spain in addition to a liberal supply from domestic sources. Spelter stocks are about 20,000 tons.

Of the smelting plant being erected in India the correspondent says it "cannot hope to show better results than were attained in Japan, where the industry is now almost extinct, first, because Indian workmen are unsuited to the labor; second, the coal is of inferior quality; third, no discovery of high-class clay for retorts has been announced."

The whole of the zinc mines of North Africa are shut down, and the output of ores in Spain is limited to the dwindling requirements of Belgium and Germany.

Australian conditions mean a considerable reduction in the production of zinc concentrates at Broken Hill, and that the annual output will fail to reach the maximum of the contract of the British Government with the producers. With the hydro-electric power available in Tasmania the output of spelter will be limited to the 5000 tons annually that can be turned out at Port Pirie. The electrolytic plant at Risdon in

Tasmania is producing about 6000 tons per year and is unlikely to exceed the requirement of the contract with the British Government.

Some time in the remote future Belgian production, with its present advantages of labor and fuel, may be supplanted by electrolytic production in Scandinavia, owing to the abundant water-power available there.

France will re-enter with pre-war production in about two years. Spain has possibilities more as a zinc-oxide than as a metal producer. Russia will take years to recover. England is in a hopeless position. India's efforts are unlikely to meet with greater success than Japan's. The United States production will be limited to domestic demand.

WORLD'S PRODUCTION OF ZINC (*a*)
(Smelter output, in metric tons)

Country	1914.	1915.	1916.	1917.	1918.	1919.	1920.
Australia (*c*)	5,094	5,393	5,362	4,769	5,712	3,625	3,909
Austria	(*b*)	(*b*)	(*b*)	(*b*)	(*b*)	(*e*)4,000	.....
Belgium	145,925	51,660	22,930	10,290	9,245	19,860	83,046
Canada	.....	20	2,698	9,058	11,139	11,182	16,798
China (*d*)	311	2,329	775	432	129	109	.....
France	42,473	19,180	20,258	22,929	18,347	10,800	20,141
Germany (*f*)	236,000	195,000	196,000	181,000	236,000	(*e*)148,000	95,758
Great Britain (*f*)	50,000	45,000	60,000	50,000	50,000	35,000	24,500
Holland	16,453	11,130	12,102	4,062	680	.....	2,031
Italy	.....	.....	258	367	1,188	1,282	1,172
Japan	5,881	21,132	38,994	(*f*)54,606	(*f*)39,834	(*e*)22,000	(*e*)8,000
Norway	19,000	25,000	32,000	22,000	1,855	(*e*)3,400	1,836
Russia (Poland)	6,300	2,000	1,100	(*b*)	4,893	(*e*)2,500	.....
Siberia	.....	.....	213	569	(*b*)	(*b*)	.....
Spain	11,733	8,117	8,523	10,155	15,900	16,310	(*e*)6,200
Sweden	2,300	8,588	9,997	7,979	4,098	2,319	1,450
Tasmania	.....	.....	.....	49	3,883	3,727	5,911
United States	320,279	444,082	606,307	607,423	469,853	422,520	420,366
Total	861,749	838,631	1,017,517	985,688	875,156	706,634	.....

(*a*) From official reports of the various countries, except as noted. (*b*) Statistics not available. (*c*) Except Tasmania. (*d*) Exports. (*e*) Estimated. (*f*) Imperial Mineral Resources Bureau, London.

Australia.[1]—Toward the close of last year the Tasmanian Parliament authorized the Government to spend £500,000 in harnessing Lake Rolleston on the west coast of Tasmania to supply the Mount Read-Rosebery Mines, Ltd., with power for the production of 50 tons of spelter per day from the group of mines owned by this company. It is now officially announced that this scheme has been dropped, and in its place the Electrolytic Zinc Co. Proprietary of Australasia, which for some time past has been producing zinc at Risdon, near Hobart, from New South Wales ores, has taken over the mines and other assets of the Mount Read-Rosebery Co.

The new proposals contemplate that the Electrolytic Zinc Co. will in due course (*a*) take over the Mount Read-Rosebery Co.'s option

[1] *Comm. Rept.*, Oct. 25, 1920.

to purchase from the Government the Zeehan smelter site, with all plant, machinery, and buildings thereon; (*b*) carry on mining operations at the Mount Read-Rosebery mines near Rosebery and Williamsford; (*c*) establish on the Zeehan smelter site a plant for the reduction, smelting, and concentration of west-coast zinc and lead ores, whether produced by itself or by others; (*d*) transport the zinc concentrates produced at Zeehan over the Government railway to Strahan, and ship thence to Hobart, where the zinc concentrates will be treated under conditions similar to those now existing in regard to the concentrates brought from Broken Hill.

The Government is to: (*a*) purchase from the Mount Lyell Copper Mining Co. a supply of electrical energy to be delivered at that company's power station at Lake Margaret, west coast of Tasmania, where the company has available a surplus of about 300 hp. not required for its own purposes; (*b*) erect a transmission line from Lake Margaret to Zeehan, with the necessary step-down station and transformers at Zeehan; (*c*) have available for sale a supply of about 1500 hp. for mining and other purposes in the Zeehan district; (*d*) sell to the Electrolytic Zinc Co. the necessary electrical energy at the Zeehan smelter site for operation purposes.

The companies state that it has been found uneconomical to establish a second zinc decomposition plant in Tasmania, with consequent and unnecessary duplication of capital, interest, and depreciation costs, scientific staff and management maintenance, and overhead charges. Consequently an amalgamation of interests has been decided upon as desirable for both companies, particularly in view of the competition with very strong companies in other countries operating on a large scale. Over 90 per cent. of the anticipated production has to be exported. The Electrolytic Zinc Co. proposes to increase its capital from £1,000,000 to £2,500,000.

It is also officially stated that the present plant of the Electrolytic Zinc Co., which was erected to prove the process in all its details and has been running since January, 1918, is now producing 15 tons daily of the highest-grade zinc, assaying over 99.95 per cent. The construction of the plant to produce 100 tons per day of electrolytic zinc, together with substantial tonnages of various by-products, is steadily proceeding. The whole of the electrical equipment for 30,000 hp. is expected to arrive at Hobart before the end of the year. The construction of the main wharf, 1000 ft. long and 60 ft. wide, is expected to be completed in four or five months' time, and work has been started upon various other parts of the plant.

During the war the British Government contracted for the purchase

of Australian zinc concentrates over a period of 10 years following the declaration of peace. Announcement was made in Parliament on Dec. 6, 1920, that production in Australia has been suspended at Broken Hill during the past 12 months, owing to a strike, and no concentrates have been acquired since Jan. 1, 1920. Stocks of concentrates are held in Australia by His Majesty's Government amounting to 503,000 tons. The British Government is not prepared to recommend any extension of the present buying operations.[1]

Belgium.—Before the war, Belgium was the third greatest zinc-producing country in the world. She owed her position to the ability and experience of her metallurgical engineers and zinc workers, to the high quality of her refractory material, and to the cheapness of her coal. The Belgian mines being long ago exhausted the smelters are exclusively provided with foreign ores from Australia, Spain, and Sweden. Broken Hill ore was used in most of the plants, and the Belgians were the first to succeed in the treatment of that complex ore. The recovery in zinc, lead, and silver which they have been able to obtain has not yet been surpassed. Except the Vieille-Montagne, which owns mines in France, Sweden, Algeria, and in other countries, the zinc companies of Belgium are totally dependent on ores from foreign countries. Belgium has to import the ore to her smelters and export the zinc to the consumers; and lacking in shipping, is dependent on other countries. The zinc plants were not wholly destroyed during the war, Germany having a large interest in many of them. Nevertheless, the plants of La Vieille-Montagne, in Baelen, the zinc works of the Dumont Frères Cie., in Silvio-peaux, and the works of Boorn were completely dismantled; but the works of Overfelt and Lommel suffered little from the wrecking effects of the German army.[2]

YEARLY PRODUCTION OF ZINC IN BELGIUM, 1913–20

Year.	Number of Retorts.	Number of Workers.	Tons of Coal.	Ore Used, Tons.	Zinc Produced, Tons.
1913	43,453	8,529	998,655	488,730	204,220
1914	30,765	8,142	715,815	340,700	145,925
1915	10,448	4,397	262,020	124,890	51,660
1916	5,182	4,044	142,020	59,750	22,930
1917	1,898	1,586	81,080	27,100	10,290
1918	1,643	764	64,430	23,190	9,245
1919	9,040	3,714	117,850	52,590	19,860
1920	.....	....	.....	.....	83,046

The Nouvelle Montagne Co., of Belgium, produced in 1920 5120 tons of raw spelter, and 4438 tons of zinc sheets.[3]

La Vieille-Montagne (the largest European zinc company) in 1920 produced 19,080 tons of raw zinc and 70,000 tons of finished zinc products, in comparison with 130,000 tons of the latter annually before the war.

[1] *Comm. Rept.*, Jan. 8, 1921.
[2] *Eng. Min. Jour.*
[3] *Metal Bull.*

Only two Belgian plants manufacture lithopone. They are the Société Anonyme des Produits Chimiques de Wilsele, near Louvain, and the Société Anonyme Stella, at Haren, north of Brussels. Their joint annual production is 16,000 tons.

The production of other zinc products is still considerably below the pre-war figures. While 9118 tons of zinc oxide was prepared in 1913, the figures for 1920 show only 1500 tons produced. In 1913 Belgian factories turned out some 300 tons of zinc chloride, but the production in 1920 amounted to only 50 per cent. of this figure.[1]

The Belgian imports of zinc ore last year were 261,984 metric tons, against 129,819 tons in 1919. The exports of spelter during the same period were 17,708 tons against 4142 tons in 1919 and 141,558 tons in 1913.

Canada.[2]—The production of zinc in 1920 amounted to 40,166,200 lb., which at the average price for the year of 7.671 cts. per lb. would be worth $3,081,149, as against 32,194,707 lb. valued at $2,362,448, or an average of 7.338 cts. per lb., in 1919.

The production in 1920 included 18,517 tons of refined zinc produced at Trail, B.C., and 1566 tons being the estimated recoveries from 4967 tons of ore and concentrates shipped to United States smelters (20 per cent. being allowed for smelter losses). The production in 1919 included 12,326 tons of refined zinc and 3771 tons of recoveries from ores exported.

The total zinc ore and concentrates shipped from the mines in 1920 amounted to approximately 247,089 tons with a metal content of 89,209,-108 lb. of zinc, as against 135,535 tons containing 59,959,709 lb. of zinc in 1919.

The production, as in past years, was derived mostly from the lead-zinc mines of British Columbia, with the exception of 1,120,200 lb. credited to Quebec.

The exports of zinc in 1920, as reported by the Department of Customs, were: Zinc ore and concentrates 3126 tons, valued at $122,387, or an average of $39.15 per ton; and spelter 6,979,900 lb., valued at $512,279. In 1919 the exports were: Zinc ore and concentrates 6630 tons, valued at $296,212 or an average of $44.68 per ton, and metallic zinc 7,693,800 lb., valued at $701,249.

The imports of zinc as reported by the Canadian Customs Department in 1920 were valued at $1,900,920, as against a value of $1,865,531 in 1919.

France.[3]—The zinc smelter of St. Amande-les-Eaux is practically the only one now working in northern France. The works did not suffer particularly from the German devastation, so that it was possible to

[1] *Comm. Rept.*, July 2, 1921.
[2] Prelim. Rept. Min. Prod. of Canada, 1920, Can. Dept. of Mines.
[3] *Min. Jour.*, Sept. 4, 1920.

re-start the plant last March. At present three furnaces are blown in, as compared with twelve in 1914, the limitation being due to shortage of fuel, as well as uncertainty with regard to ores, though the furnaces themselves are in good condition. Power is supplied from three boilers and two engines, which have now been thoroughly repaired. The machinery for retort making and for mixing the ores escaped even more lightly than the rest of the works, and was left practically undamaged, so that crucibles and melting pots are being produced normally.

The smallness of the output is also affected by the very small local demand for zinc. Very few of the existing galvanizing plants are re-conditioned, and the requirement of metal for this purpose is almost negligible. Of the very numerous undertakings which formerly existed through the whole Valenciennes area, only three or four have made an attempt at re-starting.

Germany.—According to a statement in the German technical press, the situation of the Upper Silesian spelter industry is regarded as not altogether unfavorable, notwithstanding the falling-off in foreign business owing to Government restrictions. Considerable tonnages of metal have still to be delivered, however, against contracts already entered into. It is confidently believed that Russia will in the future, as in the past, absorb large quantities of spelter from the Upper Silesian works. The zinc-sheet position is also believed to be fairly good, partly in consequence of the increased use of this material as a substitute for other metals. The supply of zinc ore has fallen off, but this is believed to be only a temporary matter, and capable of readjustment as industry improves.

Italy.[1]—The zinc electrometallurgical industry in Italy appears to have made appreciable progress of late, the sulphuric-acid method being employed as the simplest for the treatment of low-grade ores and blendes. The first experiments were initiated in 1917 with a small plant, but in the same year the undertaking was placed on a commercial basis. During the experiments calcined and crude zinc ore from Lombardy and Cerdena were used. The Italian patent was secured by the Italian Edison Co. and two allied firms. At the present time the works are using various Italian blendes, for which a special calcining furnace has been constructed. The yield in metal has varied from 82 to 92 per cent., while the consumption of current is said to have been low. One of the greatest difficulties experienced has been the refining, as traces of cadmium, lead, copper, iron, antimony, and arsenic are present in the ores. The Edison plant, however, claims to have been able to obtain metal running between 99.6 and 99.9 per cent. pure.

[1] *Metal Bull.*, Sept. 7, 1920.

Japan.[1]—The following table shows that the production of zinc ore has been steadily declining since 1913, but that the output of refined zinc increased until 1918, in which year a decrease is shown:

Years.	Zinc Ore.		Refined Zinc.	
	Metric Tons.	Value.	Pounds.	Value.
1913	34,676	$472,303	(a)	(a)
1914	14,138	140,752	13,140,265	$682,454
1915	6,121	179,845	46,958,601	6,456,866
1916	2,187	91,257	86,652,236	13,567,052
1917	163	13,576	121,596,436	13,462,153
1918	(a)	(a)	88,701,073	8,838,867

(a) Production not stated.

The estimated cost of production of refined zinc at the smelters is about $11 per picul, or 8⅓ cts. per lb. Prices of 98-per cent. pure zinc per picul ranged from $6.41 in June, 1914, to $27.40 in December, 1915. Since then prices have hovered around $12 as an average. In March, 1920, the price per picul was $13.96.

The imports into Japan of zinc ore, of ingots, slabs, and grains, of sheets, and of waste during the past five years were as follows:

Year.	Ore, Pounds.	Slabs, Pounds.	Sheets, Pounds.	Waste, Pounds.
1915	(a)	6,487,784	1,210,100	11,125,057
1916	(a)	7,218,985	1,203,998	4,401,937
1917	207,450,533	10,015,693	2,694,150	1,633,445
1918	133,093,068	5,443,656	2,981,136	1,622,656
1919	61,845,733	12,629,181	3,276,672	722,444

Since 1918 imports of zinc ore have decreased considerably, owing to a smaller foreign demand for the refined article, thus causing many smaller smelters in Japan to suspend operations.

Although no definite statistics in support thereof can be presented, indications are that foreign refined zinc and zinc manufactures, principally sheets from the United States, will once again find a growing market in Japan, owing to transshipping and speculative activities in connection with the increased demand for plating in China.

Japanese exports of zinc ore and of ingots and slabs from 1915 to 1919 are given as follows:

[1] *Comm. Rept.*

Year.	Zinc Ore.		Zinc Ingots and Slabs.	
	Pounds.	Value.	Pounds.	Value.
1915	13,618,260	$179,846	(a)	(a)
1916	4,865,332	91,258	51,586,452	$ 9,596,461
1917	362,400	13,576	81,853,012	10,442,511
1918	11,332	234	37,739,584	4,519,766
1919	(a)	(a)	12,629,180	1,463,480

(a) Statistics not available.

Russia.[1]—Beds of zinc ore occur in north Russia on the Murman coast; in the Caucasus in Terek, Kuban, and Batum governments; in western Siberia in the Kirghiz Steppes; in the Altai region of western Siberia; and in the Ussuri and Nertchinsk regions of eastern Siberia. Prior to the war there was in these regions a yearly production of metallic zinc of 650,000 to 750,000 poods (1 pood = 36.11 lb.), which was only a fraction of Russia's requirements of this metal. The various reasons for the lack of development of this industry and the working exclusively of mines containing a high percentage of ore are remoteness of the zinc mines from the industrial centers, sparse population, poor communication, severe climate, lack of fuel, and high transportation charges. For instance, the Ridder Mining Corporation, of Altai, produced a concentrated solution of zinc which had to be sent by a specially constructed railroad, to Ust-Kamenogorsk, on the River Irtysh, downstream to the city of Ermak, and then by the Voskresensk Railroad to the Eskibastur coal mines, Semipalatinsk region, where metallurgical works for the treatment of this concentrated solution were erected.

The Russian production,[2] imports, exports, and consumption of zinc (including sheets and rods) from 1863 to 1914 were as follows:

Year.	Production of Zinc, *Poods.*	Imports, *Poods.*	Exports, *Poods.*	Home Consumption, *Poods.*	Home Production in Consumption, Per Cent.
1863	65,000	13,000	.....	78,000	83.3
1873	206,000	111,000	.....	317,000	64.9
1883	224,000	148,000	.....	372,000	60.2
1893	275,000	500,000	2,000	773,000	35.6
1903	604,000	623,000	3,000	1,224,000	49.3
1913	644,000	1,719,000	5,000	2,358,000	27.3
1914	397,000	1,390,000	2,000	1,785,000	22.2

This table shows that as the demand for zinc increased, the rôle that the home industry played diminished and the imports increased accordingly.

[1] *Comm. Rept.*, Oct. 25, 1920.
[2] *Comm. Rept.*, Oct. 25, 1920.

Zinc ore was mined in Russian Poland, the Caucasus, and eastern Siberia in the following quantities in 1904 and from 1910 to 1914:

Regions.	1904. *Poods.*	1910. *Poods.*	1911. *Poods.*	1912. *Poods.*	1913. *Poods.*	1914. *Poods.*
Russian Poland	6,159,000	3,565,000	3,300,000	3,572,000	4,038,000	2,000,000
Caucasus	4,000	486,000	603,000	577,000	761,000	587,000
Eastern Siberia	.....	971,000	1,490,000	1,740,000	1,633,000	1,289,000
Total	6,163,000	5,022,000	5,393,000	5,889,000	6,432,000	3,876,000

In Russian Poland for the last 10 years before the war the production of zinc diminished, owing to the exhaustion of the Olkusz mines. The increase for the years 1912 and 1913 was due to the discovery of new unimportant fields. In the Caucasus the zinc industry began in 1904 and continued to develop. The figures for the Caucasus represent ore not as it is mined but after it is sorted from the lead ore. In eastern Siberia the production of the zinc mines of the Tetiukhe Corporation exceeded 1,500,000 poods in 1912 and 1913, but no greater increase in production can be expected, as lead ore predominates over zinc ore in the mines of this corporation. The zinc ore from the Usuris region was exported without being smelted.

The following table shows the product of zinc smelting in Russian Poland and the Caucasus from 1910 to 1914:

Regions.	1910. *Poods.*	1911. *Poods.*	1912. *Poods.*	1913. *Poods.*	1914. *Poods.*
Russian Poland	527,000	606,000	535,000	501,000	250,000
Caucasus	135,000	139,000	180,000	180,000	147,000

United Kingdom.[1]—Of the 12 spelter works in Great Britain 7 are in the consular district of Swansea, Wales; of the others, 3 are in northern England, and 2 are in Scotland. The total capacity of the Swansea works is put at about 300 tons per day; but the works have never run at their full estimated capacity, and during the last half of 1919 did not attain an output of as much as 100 tons per day. The spelter industry of the United Kingdom had its commercial beginning in south Wales in the early part of the last century, and for many years Swansea has been the center of that industry.

The output of zinc ore in the United Kingdom is not large, being at best hardly 15,000 tons per annum. The deposits lie in Cumberland, Northumberland, south Scotland, and north Wales. By far the greater part of the ore smelted is imported. The imports to the

[1] *Suppl. to Comm. Rept.*, Dec. 1, 1920.

entire United Kingdom for 1913, 1918, and 1919 are given in the table which follows, and of the totals given, the district of Swansea imported 39,827 tons in 1913, 78,996 tons in 1918, and 53,577 tons in 1919.

Countries of Origin.	1913. Tons.	1918. Tons.	1919. Tons.	Countries of Origin.	1913. Tons.	1918. Tons.	1919. Tons.
Germany	7,169	.....	.....	Spain	6,348	39,596	7,214
Algeria	9,302	24,066	1,464	Other	11,278	12,105	3,868
Australia	16,772	3,359	45,018				
Italy	13,801	13,661	20,988	Total	64,670	92,787	78,552

The country seems to find it more profitable to import its supplies of spelter than to smelt imported ores. The imports of spelter into the entire United Kingdom for the years 1913, 1918, and 1919 were as follows:

Countries of Origin.	1913. Tons.	1918. Tons.	1919. Tons.	Countries of Origin.	1913. Tons.	1918. Tons.	1919. Tons.
Australia	186	.....	739	Norway	.....	5,591	2,375
Belgium	53,500	4	2,818	United States	4,670	50,495	68,333
Canada	962	815	8,034	Other	2,291	7,209	7,063
France	5,915	9	886				
Germany	64,179	.....	473	Total	145,004	64,138	94,226
Netherlands	13,301	15	3,505				

The smelting industry received decided stimulus during the war. This was particularly true of the Swansea works, whose imports of zinc ore in 1918 were just double those of 1913. Since the close of hostilities the industry has set into a steady decline; and with the close of 1919 the outlook was very discouraging.

Metallurgy of Zinc in 1920

By W. R. Ingalls

The dominant features in the zinc industry of the world at the present time are the enormous extent to which the American industry is overbuilt, the chaotic conditions of production in Europe, and the imminence of new metallurgical developments that will inevitably exert a powerful influence upon the markets of the world.

Between the end of 1914 and the end of 1916 the zinc-distilling capacity of the United States was increased from a basis of 400,000 tons of zinc per annum to a basis of 800,000 tons, besides which 35,000 tons of electrolytic capacity was added. Pre-war consumption in the United States was about 300,000 tons. In my opinion the American zinc industry is now confronted by a reorganization to the basis of about 400,000 tons per annum, which would give the same surplus of capacity as in

1914. During 1918 and 1920 some of the distillation plant was scrapped, but the electrolytic plant was increased, and at the end of 1920 we still had capacity for the production of 700,000 tons of slab zinc per annum, wherefore a further writing off of 300,000 tons must be contemplated, unless use can be found for it.

Some of this surplus capacity was paid for under pre-war conditions; some of it at the higher prices that subsequently prevailed. Some of it is in natural-gas plants and some of it in coal-fired plants, which are more costly. But if I should generalize the capitalization of that capacity, not in terms of replacement value, but rather in terms of its brick and steel and labor when built—if, in other words, I should estimate its cost at $10,000,000—I think that my estimate would be conservative.

There was a similar surplus of mining and milling capacity created during the war. At the middle of 1918 I estimated that this, on the basis of 300,000 tons of spelter per annum, represented about $10,000,000. How much of that had been discarded up to the end of 1920 I have no idea.

The zinc industry of Europe has not yet regained its pre-war proportions, and shows but little sign of recovery.

Commercial Conditions.—The zinc industry suffered from the general economic conditions of 1920. Early in the year production was maintained at a high rate, although much below the maximum during the war. In view of the bad situation as to zinc production in Europe, it was anticipated that the United States would be called upon to export at least 100,000 tons of spelter during 1920. In fact, buying for export began as was expected and for several months continued on a large scale, but at about the mid-year this ceased, and Europe began presently to re-sell to us our own spelter. Following this the price, which had risen to about 8 cts. as the maximum for 1920, declined, about 5½ cts. being quoted toward the end of the year. The contraction in domestic demand was such that in spite of greatly curtailed production unsold stocks accumulated rapidly and to a large figure.

The production of spelter in Europe in 1920 was small in comparison with pre-war figures, but it became clear that the European ability to buy spelter was greatly inferior to the sharply diminished supply. Europe also had a very large stock of spelter at the mid-year, and at the close of the year the quantity was still large. This was in spite of the fact that the zinc production of Belgium and Germany in 1920 was far below pre-war figures, while in Great Britain zinc smelting practically ceased.

In the United States zinc production was largely governed by the mines of Oklahoma, which were able to sell blende concentrates for low prices, in spite of high mining and milling costs, owing to the good grade

of the ore mined. With blende of 60-per cent. grade selling for less than $30 per ton, at the end of 1920 there were still 34 mills in operation, and the weekly output of concentrates was upward of 5000 tons. Even with conversion cost of $25 per 2000 lb., ore at $30 per ton meant 5½-ct. spelter, but the true economic cost, which markets temporarily ignore, was undoubtedly much higher.

The price for lead-free zinc oxide was 10 cts. per lb. during most of 1920. Late in the year it was reduced to 9½ cts. The producers of zinc oxide were seriously affected by the curtailment of production by the manufacturers of automobile tires.

Altogether, conditions in 1920, especially in the second half of the year, were such as to produce general gloom in the zinc industry.

Labor Conditions.—I have made an investigation of the variations in labor requirements in zinc smelting in the United States, the wages paid and the metal losses, several smelters having reported to me on this subject. All of the figures refer to the ton (2000 lb.) of raw blende smelted.

In 1914–15 the smelting of a ton of blende required the labor of from 2 to 2½ man-days. The average daily wage was about $2.20. There were no extraordinary variations in the figures for these years.

On the other hand, the figures for 1920 show wide variations. Thus, one very important smelting company reported a slight increase in the man-days of labor, but both for 1914 and 1920 the figure was close to 2½. Another important works reported an increase of about 7½ per cent. On the other hand, there were some works reporting increase in the labor requirement up to 3¼ man-days per ton of ore. I think that a safe general deduction from the data is that if the average labor requirement in smelting a ton of blende in 1914 was 2¼ man-days, in 1920 it was 2½ man-days.

There is more uniformity in the reports as to average rate of wages, as will appear from the following tabulation:

Works.	1914.	1920.
A	$2.20 to $2.49	$4.74 to $5.20
B	2.20	5.87
C	.....	4.73
D	2.17	5.35

It is clear from the above figures that the average rate of wages paid zinc smelters increased from 1914 to 1920 by 2 to 2.67 times.

There is also considerable variation in the reports of metal losses. In quoting these I shall refer to units; *i.e.*, if I say that loss is increased, and vice versa extraction diminished, by 2 per cent., I shall mean that if extraction were 86 per cent. and losses 14 per cent., the variation of 2 per cent. means the extraction of 84 per cent. and loss of 16 per cent.

One important smelter reports that its extraction of zinc in 1920 was almost exactly 2 per cent. less than in 1914. Another gives the same figure. Another reports a decline of 3 to 5 per cent. Another shows a decreased extraction to the extent of 3.6 per cent. It may be deduced from the above figures that the average extraction of zinc in smelting in the United States decreased from 1914 to 1920 at least 2 per cent., and maybe 3 per cent.

Insofar as 1920 is concerned, all of the above figures refer to conditions at the mid-year when everything was about at the worst. After that there was improvement. One large smelter, who did not give any specific figures, reported that during the first six months of 1920 furnace work was very poor, but since then the results had been very much better; and, in fact, in November they were as good as in 1914, and in some instances were better.

The figures of one smelter, summarizing the results year by year expressed in terms of percentages on the basis of the figures for 1915, taken as 100 per cent., are given in the following interesting table.

FURNACE LOSSES

1915.	1916.	1917.	1918.	1919.	1920.
100	121	116	127	134	146

MAN-DAYS PER TON OF RAW ORE SMELTED

1915.	1916.	1917.	1918.	1919.	1920.
100	95.9	99.5	104.6	105	107.6

MAN-DAYS PER TON OF ZINC PRODUCED

1915.	1916.	1917.	1918.	1919.	1920.
100	98.4	96.5	102.7	103.2	105

AVERAGE HOURLY WAGE OF FURNACE MEN

1915.	1916.	1917.	1918.	1919.	1920.
100	136	164	209	227	267

The deduction to be drawn from the collection of figures on this subject, as the record of a sad experience in economic history, is simple. The zinc smelters, meaning the workmen, of the United States during the period from 1914 to 1920 received a great increase in their rate of wages, in consideration of which they did less work per man, as reflected by the greater number of man-days required to smelt a ton of ore, and even their diminished rate of working was with impaired efficiency, as is reflected by the decrease in the percentage of zinc extraction. This is quite in line with the record of labor in other industries.

Blende Roasting.—For the dead roasting of blende, as a preliminary to distillation, the same old furnaces are used. There is great need for something better, but invention and initiative seem to be lacking. More attention should be given to thermal studies. In this connection the results of the new furnaces that the Wedge Mechanical Furnace Co. has

erected at Cuba City, Wis., will be awaited with great interest; for in its design attention has been directed especially to thermal conditions, both as to the conservation of heat and its development in the right parts of the furnace. It is expected with this furnace to dead-roast zinc blende without the assistance of any extraneous heat. Theoretically this is possible.

Roasting for the electrolytic process is done generally in furnaces of the McDougall type. These are built now for such conservation of heat and such transferal of heat by the circulation of air through the furnace as I indicated ought to be done in my U. S. Patent No. 786,567 of Apr. 4, 1905. The thermal features of that design were not claimed in the patent, for they were simply what should follow from sound metallurgical considerations.

Distillation.—Mr. William A. Ogg, in the bulletin of the American Zinc Institute for November–December, 1920, defended the American practice in distillation against some criticisms that had been made. I think that there is a good deal of merit in his contentions. Mr. Ogg gave the following comparative figures for coal consumption per ton of ore distilled with the reversing regenerative furnaces at Rose Lake and the Hegeler furnaces at Hillsboro:.

	Rose Lake.	Hillsboro.
Furnace fuel	1.00	1.60
Power and steam	0.50	0.10
Drying and roasting	0.30	0.30
Pottery and miscellaneous	0.05	0.05
Totals	1.85	2.05

The low consumption of furnace fuel at Hillsboro is very creditable, considering the inferiority of the Illinois coal. Mr. Ogg puts the plant cost of the reversing regenerative furnace at twice that of the Hegelers, and rates repair costs higher. Mechanical gas producers are used at both plants.

A development of interest at Palmerton where, of course, the conditions are unique, has been the successful operation of the distillation furnaces with the excess gas from the blast-furnaces smelting spiegeleisen. Inasmuch as these gases contain some zinc, resulting from the Wetherill furnace residues that are smelted, there was a gas-purifying problem, which was solved by settling chambers followed by Theissen washers. The gas is then piped to the zinc distillation furnaces. The gas from the spiegeleisen blast-furnaces is higher in carbon monoxide than that of the ordinary blast-furnace. It averages about 33 per cent. in carbon monoxide. Inasmuch as there is not sufficient of this gas at Palmerton for the entire requirements of the zinc distillation furnaces, it is mixed with producer gas. There has been no difficulty in handling the mixture.

At the works of the National Zinc Co., Bartlesville, Okla., considerable work has been done in the trial of cleaning-out machines. Some years ago a German machine was tested. Although it cleaned the bottom of the retorts it did not get at the sides. Another trouble was that the variations in the angles of the retorts resulted either in the punching of a hole in the bottom or the failure to clean at all. Another trouble was that the loam around the retorts was more or less loosened by the vibration, which meant reloaming after charging, or if this were not done the gas from the furnace would overheat the butt of the condenser, thereby causing loss of zinc. Last year a new cleaning-out machine was developed at these works which is very simple and appears to be successful. It is based on the idea of operating the ordinary shovel or spoon, constructed a little more substantially, by means of friction rollers, the shovel itself being guided and manipulated by hand. The mechanism that carries and motivates the friction rollers runs on a track in front of the furnace. Formerly two men per furnace were required for cleaning out residues. With the new machine the two regular shovelers run it and do all their regular work besides. It takes only one man to operate the machine, but they alternate, each man cleaning eight retorts. The furnace is kept so clean that increase in charges is permitted, the furnace equipped with the apparatus using only about 60 per cent. as many retorts as the other furnaces on the same ore. It takes about 15 to 20 min. longer to clean the furnace than by hand, but this time is gained by having fewer retorts to charge. The machine requires only 4 hp. to operate and probably will not cost more than $800, including the motors.

Electrothermic Smelting.—Electrothermic smelting has been practiced on a commercial scale in Scandinavia, especially at Trollhattan and Sarpsborg. Besides these, there are one or two smaller plants. A new plant is being built at Glomfjord. This is to have capacity for smelting 60,000 metric tons of ore per annum. At the end of 1920 it had not been completed, but construction was well advanced. The electric furnaces used for ore smelting in Scandinavia are resistance furnaces, and are designed and run as combined zinc and lead smelting furnaces, both zinc and lead being obtained in the same operation, the gangue of the ore being fluxed and drawn off as slag. In the new process recently developed at Trollhattan the lead is completely volatilized and no attempt is made to condense the zinc as spelter. The vapor is rapidly cooled, the metals condensing as powder, which is subsequently melted down, affording a very leady spelter, which is finally refined by redistillation in an electric arc furnace. The ore smelting furnace is operated on the principle of producing a highly silicious slag, which commonly contains about 50 per cent. silica.

Electrical power is relatively cheap in Scandinavia and in the operation of large furnaces, e.g., for the smelting of 10 tons of ore per 24 hours, to which the Scandinavians have arrived, certain difficulties that used to be experienced in 1-ton or 2-ton furnaces have disappeared, or at least have been greatly ameliorated.

Dr. C. H. Fulton at a recent conference in St. Louis said that he is still a firm believer in electrothermic smelting and that his experimental furnace in St. Louis had distilled three charges of 4000 lb. each in 24 hr., with a consumption of only 1450 kw.-hr. per ton of zinc ore, and a recovery of zinc higher than by ordinary distillation.

Electrolytic Extraction.—It seems to me that the most important thing in the metallurgy of zinc in 1920 was the thorough proving of the electrolytic process. When that process was first introduced, in 1916, I prophesied its success and the enormous influence that it would have on zinc production, but I foresaw its limitation to especially favorable conditions. In other words, it seemed to me that the experience in the zinc industry would be similar to what it had been in the sulphuric acid industry, following the introduction of the catalytic process. At that time it was prophesied that the chamber process would be supplanted, but in fact that did not happen at all. I never had any idea that electrolytic zinc extraction would displace distillation, but I appreciated that the electrolytic process had come to stay, and could meet any competition when introduced under suitably favorable conditions. My forecast has been exactly verified by experience. Some of the small electrolytic plants that were erected and operated during the war have been dismantled since then, but the great plants at Great Falls, Trail, and Risdon have continued in operation, and indeed upon a larger and larger scale. The Risdon plant is now being enlarged to a capacity for the production of about 40,000 tons of spelter per annum. The completion of the work that will give such a capacity is to be expected about the end of 1921. With such a capacity for Risdon, with Great Falls at 60,000 tons per annum and Trail at 10,000 tons, and with one or two smaller plants, the world will have a capacity for the production of electrolytic zinc at the rate of about 120,000 tons per annum, which will be upward of 10 per cent. of the rate of the world's total pre-war production. This can not fail to be an important factor in the zinc industry. Of course even the present production, combined with the production of high-grade spelter by distillation, has so increased the supply of that class of zinc that the old premium for it has been greatly reduced.

In the course of its development great improvements have been made in the electrolytic process. For example, it has become possible so to roast the ore that no sulphuric acid is required for the lixiviation of the

zinc; the removal of impurities interfering with the electrolysis has become much more easily manageable; and so on. In the light of these developments the limitations of the electrolytic process do not seem to be so severe as they did four years ago. In other words I can now see the electrolytic process as a more powerful competitor of distillation. However, the factors remain that the electrolytic process must be conducted on a large scale and the cost of plant per unit of capacity is greater than that of the ordinary plant.

The technology of electrolytic zinc extraction has been fully and ably described in two recent papers; one by Herbert R. Hanley, in *Mining and Scientific Press*, Dec. 4, 1920; the other by Frederick Laist, F. F. Frick, J. O. Elton, and R. B. Caples, presented at the New York meeting of the American Institute of Mining and Metallurgical Engineers, February, 1921.

Zinc Burning.—Considerable improvements have been made in the art of burning zinc out of ore, either for the production of pigment or for the production of fume to pass to another metallurgical process for further treatment. As to the latter, electrolytic extraction seems to be the only thing that is immediately available. When the electrolytic process was abandoned at Keokuk, Iowa, the fume produced at Florence, Colo., that previously was dispatched thither, no longer had that outlet, and as a substitute for it Wetherill furnaces were erected at Florence, in which the crude fume from the reverberatory furnace is reduced and re-burned for the production of pigment. The fume from the reverberatory furnace, when the latter is fired with coal dust, is naturally so contaminated as to be hopeless for the direct production of pigment. I understand, however, that the gas-firing of a reverberatory furnace for the direct production of pigment is to be attempted in California.

Metallurgically the operation of a reverberatory smelting furnace for the production of copper matte and a zinc-lead fume in one operation seems to be quite manageable, but there are problems in connection with matte-fall, slag formation, etc., that require careful consideration. Once they are properly managed the reduction of the zinc oxide, and the whole operation, appears to be capable of performance with materially less fuel and labor than is the case with the Wetherill furnace.

Wetherill practice has not been at a standstill, however, the introduction by the New Jersey Zinc Co. of the invention of its metallurgists for the burning of a briquetted charge instead of a loose charge having been a noteworthy economic improvement. A mechanicalized Wetherill furnace is to be anticipated.

A large new oxide plant was built at Columbus, Ohio, by the American Zinc, Lead and Smelting Co. during 1920, and is to be put in operation

early in 1921. This plant is built with furnaces of the Western Wetherill type, which is that generally adopted in the United States outside of Palmerton. The New Jersey Zinc Co. completed a new oxide plant at Canyon City, Colo., which also has furnaces of the Western Wetherill type.

The mechanicalized bag-house has not yet proved very successful. In one case at least it has been completely condemned.

PROGRESS IN ORE DRESSING AND COAL WASHING IN 1920

By Robert H. Richards and Charles E. Locke

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General

The year has been one of extreme depression in metal production, except for gold and silver, with the result that new development and construction have almost ceased and the operators have also been forced to conserve their resources and cut down on experimental work and alterations. Fine grinding in ball and roller mills and oil flotation still continue to receive the most attention, while coal washing is becoming more important.

Crushing and Grinding

Breakers.—A novelty in gyratory breakers is the Mitchell breaker, which is driven by an unbalanced motor on the same principle as the Mitchell screen. It is still in the experimental stage, but the results are reported as quite promising.

Underground crushing forms one of the features of the Belmont Shawmut Co.,[1] where the mine ore is dumped into a storage-bin in the

[1] A. B. Parsons, *Min. Sci. Press*, **121**, 619 (1920).

mine which feeds two No. 5D Gates gyratory breakers, set to crush through a 2-in. ring and delivering to the crushed-ore bin. The capacity of the storage-bins is 450 tons, which allows considerable elasticity in hoisting and the whole arrangement means considerable saving in equipment as well as labor.

Rolls.—Some comparisons of crushing machines showing advantage of rolls on a silver-tin ore in preparation for chloridizing roasting have been reported by M. G. F. Söhnlein.[1] Krupp ball mills with 1.2-mm. screens were originally used, but were replaced by two pairs of 36 by 12-in. rolls in series. The coarse rolls operated in closed circuit with a ⅜-in. trommel and the fine rolls in closed circuit with a 0.85-mm. trommel or with a 1.9-mm. Newaygo screen. Later a ring-roll mill was tried in place of the fine rolls. Compared with the ball mills, the two sets of rolls did the crushing for less than one-third of the cost. The ring-roll mill was uneconomical on account of its high power and steel consumption and weak points in construction which developed with use. Following are sizing tests of the products.

	Ball Mill With 1.2-mm. Screen, Per Cent.	Rolls With 0.85-mm. Screen, Per Cent.	Rolls With 1.9-mm. Newaygo, Per Cent.	Rolls and Ring Roll With 3.0-mm. Newaygo, Per Cent.
+ 10 mesh	3.0	0.0	1.5	4.0
− 10 + 20 mesh	17.0	19.0	16.0	24.5
− 20 + 40 mesh	24.0	31.5	19.5	20.0
− 40 + 60 mesh	8.5	11.0	23.0	5.5
− 60 + 80 mesh	7.0	10.0	8.	4.0
− 80 + 100 mesh	5.0	5.5	5.5	6.5
−100 + 150 mesh	3.5	4.5	4.5	9.0
−150 mesh	32.0	18.5	22.0	26.5
	100.0	100.0	100.0	100.0

Stamps.—Gravity stamps are yielding somewhat to other crushing machines, but are not becoming obsolete by any means. No man is better qualified to discuss the present status of the stamp mill than A. J. Clark,[2] who figures that three-quarters of the gold produced today comes from ore crushed in stamps, and that what stamps really need is more publicity.

The story of the development of stamps shows that their use is governed mainly by metallurgical demands. For amalgamation they seem preferable. When the demand came for granular pulp in the cyanide process the Chile mill came in, only to be displaced later by the tube mill when slimes became desirable. The all-sliming cyanide process found the stamp at a disadvantage because it gave too much dilution to

[1] *Am. Inst. Min. Met. Eng.*, Aug., 1920. *Eng. Min. Jour.*, **110**, 586 (1920).
[2] *Eng. Min. Jour.*, **109**, 833 (1920).

the pulp. We do not have to go back half a century to find stamps largely used as fine crushers for concentration—work which is now better handled by other machines.

The present field of stamps appears to be in the use of heavier stamps to make a coarser product for the secondary fine-grinding machines. The tube mill is best for fine cyanide grinding.

The special feature of the stamp is its great flexibility. Its weight may vary from 900 to 2000 lb. It gives an absolutely positive product, the maximum size of grain being limited by the screen aperture. It can handle feed as coarse as 3 in. and reduce it to fine size in one step. Thus it may have a wide range of work between the size of the feed and the size of the product, although it does not make for the highest efficiency to make too great a reduction in one stage. It does not lend itself to operation in a closed circuit.

As regards the effects of the adjustments, increased weight means increased capacity with no change in the screen analysis of the product. The probable limit for best work is 1550 lb. where five stamps drop in one mortar. The coarser the screen, the greater is the capacity, with practically all the increase in the coarser sizes as evidenced by screen analyses. The number and height of drop are interdependent. A heavy stamp can naturally have a shorter and faster drop, with the same crushing blow, than a light stamp. High discharge is to be used only for fine crushing.

The stamp seems best suited for small installations on account of its flexibility and its ability to take large feed, whereas a ball mill requires close adjustment of feed and other conditions. Its future lies in the amalgamation field, as in South Africa, with a high output from the use of coarse screens. The Nissen stamp appears preferable to the five-stamp mortar. The future may even see stamps crushing coarser than at present and followed by ball mill which in turn delivers to the tube mill for finishing.

The following table gives six examples of modern stamp work; the first is the Nipissing mill on a very hard, tough ore, the product having 55 per cent. on 20 mesh, 24 per cent. 50 to 100 mesh, and 17 per cent. through 200 mesh. The second is the Belmont mill, yielding 29 per cent. on 20 mesh, 40 per cent. 20 to 100 mesh, and 24 per cent. through 200 mesh. The third is the Homestake, amalgamating, with 8-in. height of discharge and giving 8 per cent. on 50 mesh, 17 per cent. 50 to 100 mesh, and 53 per cent. through 200 mesh. The fourth is the Homestake running experimentally and delivering 37 per cent. on 20 mesh, 28 per cent. 20 to 100 mesh, and 24 per cent. through 200 mesh. The fifth is the Santa Gertrudis and the sixth is the New Modderfontein, which uses Nissen single-stamp mortars.

Weight, Pounds.	Horsepower.	Drop, Inches.	Drops per Minute.	Pulp Dilution.	Screen, Mesh.	Tons Per 24 Hours.
1,500	3.1	8.0	96	7:1	2 & 3	6.7
1,250	2.63	6.0	104	5:1	4 & 6	8.88
900	2.04	10.0	89	10.5:1	(a)	4.5
900	2.04	10.0	89	10.5:1	3	8+
1,550	3.5	7.5	102	10:1	3 & 4	21.1
2,000	.....	.....	.....	.....	3	30.0

(a) Screen is]No.'8 diagonal slot with aperture 0.022 by 0.5 in.

The change in the new Homestake South mill to coarser crushing with heavier stamps is described later under *Crushing Practice.*

Chile Mills.—The claim of L. W. Lennox[1] that a Chile mill requires coarse material in the feed for highest efficiency and is better suited for coarse grinding has been challenged by P. H. Argall,[2] who traces the development of the use of Chile mills in the Independence mill on Cripple Creek ores and follows up with details of their work in the Ozark mill in New Mexico on sulphide ore, all along the line of successful fine grinding. In the Independence mill Chile mills took ¼-in. maximum feed and reduced it to 62 per cent. through 150 mesh. Later the feed size was increased to 1 in. maximum. At the Ozark mill a standard 6-ft. Akron Chile mill crushes 1¼-in. feed from rolls so that 66 per cent. passes 150 mesh at the rate of 160 tons per 24 hr. Comparison in the Ozark mill with a 4 by 14-ft. tube mill showed favorably for the Chile mill as a fine grinder, as evidenced by the following sizing tests.

	Chile Mill Product, Per Cent.	Ball Mill Product, Per Cent.
+50 mesh	3.8	1.4
−50 + 100 mesh	9.7	11.4
−100 + 150 mesh	12.6	20.0
−150 + 200 mesh	9.8	10.9
−200 mesh	64.1	56.3
	100.0	100.0

Argall's view is that in applying the Chile mill to coarse grinding in the Portland mill they have increased the speed, which means an increase in strength and increased cost. By reducing the width of tire from 8 in. to 7 in. the area of crushing surface is reduced 12.5 per cent. with consequent loss of abrasion. The weight of the rollers has been increased by the use of thicker tires and the annular velocity at 37 r.p.m. figures out 610.24 ft. per min. as measured along the center line of the die and rolls, as against 500 ft. per min. as the maximum economical speed. The main point is that, even though with fine feed the roll is close to the die, such feed can be ground efficiently by either increasing the width of the tire or decreasing the weight of the roller. The net result of

[1] MINERAL INDUSTRY, **28**, 750 (1919).
[2] *Am. Inst. Min. Met. Eng.*, May, 1920.

either is to decrease the pressure per square inch of crushing surface and thus allow fine ore to be fed of any desired thickness. The wide tire gives more abrasion for fine feed. With narrow tires, heavy rolls, high speed and coarse feed of thin slabby ore the Chile mill goes "bumpty bump," which is hard on the mill. It does not seem possible that the complicated and expensive Chile mill can compete with the simplicity of rolls in doing the work of coarse crushing. Argall submits tabulated figures to demonstrate the ability of properly designed Chile mills to do fine grinding efficiently.

Ball Mills.—No radical developments have occurred in this type of machine. The Dewco ball mill, type LD, has a discharge trunnion opening sufficiently large to serve as a manhole and thus avoid the use of a manhole in the side of the mill with the accompanying structural weakness. In this case the size of the discharge-opening may be reduced for actual operation by inserting at the joint between the trunnion and the flaring discharge-spout a steel plate bored with any desired size of opening.

In the Hardinge mill when run in open circuit delivering a finished product the practice sometimes develops of running with a dilute pulp to effect classification in the mill and hold back the oversize. This decreases the efficiency of the mill and a better plan is to introduce a ¾-in. pipe with a ½-in. nozzle into the discharge-end of the mill on the lifting side. The spray from the nozzle is then directed at an angle so as to hit as near as possible the point in the mill where the pulp and pebbles are cascading. The flow of water is so regulated that the pulp dilution does not get beyond 18 in. to 2 ft. from the discharge-end of the mill and thus keeps the main body of pulp thick. This device at the Bluestone Mining & Smelting Co., Mason, Nev., increased the capacity of the mill almost 10 per cent., and had no effect on the consumption of pebbles and liners because the main body of pulp was still kept at 75 to 80 per cent. solid by weight.[1]

Wearing Parts and Adjustments of Ball and Tube Mills.—For tube-mill liners of the Komata type in the Alaska Gastineau mill old roll-shells are used which have been straightened in the forge. The same material also finds various application for wearing-plates in the plant.

When a change is made from flint pebbles to hard mine-rock the capacity is reduced, due to waste of energy in rounding off the chunks of ore before they become efficient grinding mediums. One way to overcome this is to speed up the mill and round off the chunks of ore just that much sooner. At the mill of the Utah Leasing Co., 8-ft. by 48-in. Hardinge mills running at 28½ r.p.m. did not show any reduction of capacity

[1] V. A. Stout, *Eng. Min. Jour.*, **110**, 394 (1920).

when change was made from flint pebbles to local quartzite blocks, because these mills were running faster than the normal rate of 26 r.p.m.[1]

The pebble load in the tube mill at the Belmont Shawmut mill[2] is carried 10 to 12 in. below the center line for best results. This tube mill is 5 by 18 ft., receives sand that has come from stamps with 10-mesh screens and grinds so that 4 per cent. is on 48 mesh and 56 per cent. passes 200 mesh. Formerly with the pebble load up to the center line of the mill the consumption of the best Danish pebbles was 1.3 lb. per ton of ore stamped. Decrease to 10 in. below the center reduced the pebble consumption to 0.3 lb. per ton with no impairment of results, although the consumption of power increased.

The efficiency of a ball mill is dependent on rather close adjustment of various factors. T. E. Fisher[3] has constructed curves (see Fig. 1)

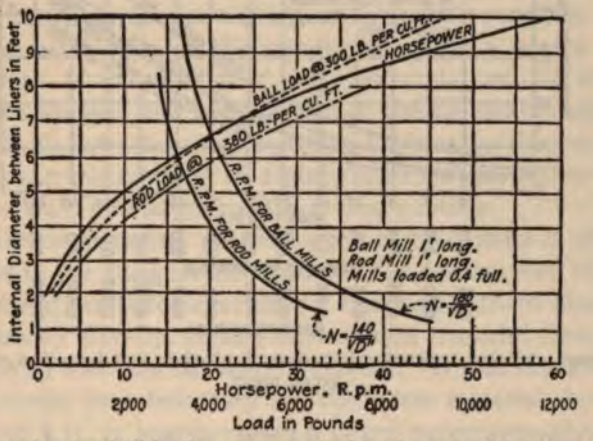

FIG. 1.—Curves showing ball load, power required, and most efficient speed for ball and rod mills.

to show the relation of these factors. These curves are for any diameter of mill between 2 ft. and 10 ft., and 1 ft. long. The ordinates are diameters inside the liners. Abscissas show speed in r.p.m. and ball loads when the mill is 0.4 full. The weights are based on a reported weight of balls of 280 lb. per cu. ft. plus an extra allowance of 20 lb. to cover friction of gears and bearings and weight of pulp in the mill. Speeds are figured from the formula N in r.p.m. $= \frac{180}{\sqrt{D}}$ where D is internal diameter in inches. The figures for rod mills are based on a weight of 380 lb. per cu. ft. and $N = \frac{140}{\sqrt{D}}$.

[1] V. A. Stout, *Eng. Min. Jour.*, **110**, 394 (1920).
[2] A. B. Parsons, *Min. Sci. Press*, **121**, 659 (1920).
[3] *Eng. Min. Jour.*, **109**, 859 (1920).

Fig. 2 shows power requirements for hard ores and for soft ores to grind one ton of 1-in. ore all through any given mesh.

The size of feed to ball mills shows a tendency to decrease. It now seems preferable to crush in breakers or rolls to 1 in. or finer.

The rate of travel through the mill is kept high. Slow travel means that much of the ore is crushed unnecessarily fine. Therefore, feed fast and return the oversize for re-grinding.

In regard to per cent. of moisture, good practice is to keep the moisture low and the pulp thick so as to coat the balls and reduce the wear of balls and liners.

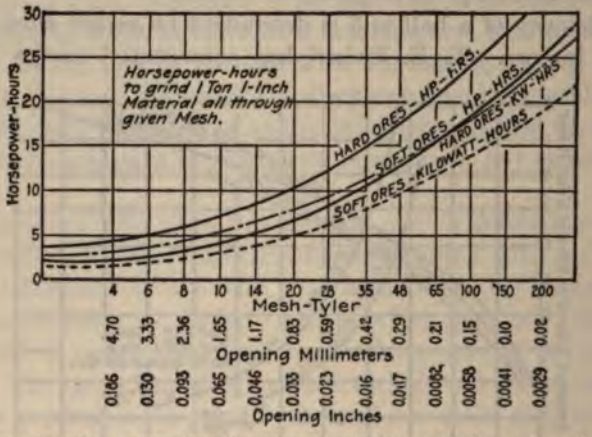

Fig. 2.—Curves showing approximate power required to grind one ton of ore through a given mesh.

Size of balls ranges from 1 in. to 7 in. in diameter, depending on the size and hardness of the ore. Best results seem to be obtained when the balls fill the mill 0.3 to 0.4 full.

The speed depends on the internal radius and is something less than the "critical" speed where the layer of balls next to the shell clings to the latter as the mill revolves. This critical speed in r.p.m. is expressed by the formula $N = \frac{54.19}{\sqrt{r}}$ where r is radius of mill in feet. The modern practice is to operate at 0.6 to 0.8 of this speed, the lower limit representing the speed at which the action is of a rolling nature and grinding is done, while the upper limit gives more cascading and impact grinding. The slower the mill the less power is consumed and the less is the capacity, so a most efficient speed exists for any particular mill.

Operators are proving that by decreasing the size of the feed they may decrease the size of balls, increase the number in the mill, secure a

greater grinding surface, cut the speed to secure a greater rubbing action and do more efficient grinding.

Closed circuit is the common practice over open circuit. The ore is crowded through the mill, classified, and the oversize returned, thus keeping the mill up to full capacity and leading to efficient work. The circulating load is four to five times the feed.

The tendency is toward large-diameter mills, 9 ft. being the limit so far. Opinion is divided as to the advisability of discharging through grates or of overflowing through the trunnion without any diaphragm. The diaphragm makes the mill more sensitive to overloading.

A theoretical explanation of the effect of thick and thin pulps in ball and tube mills is based on the laws of chance.[1] This considers both the number of particles to be hit and the number of crushing units to hit them. In a thin pulp the particles pass through too rapidly and have less chance of being hit. A thick pulp also gives a coarse discharge because the ratio of the number of particles to the number of crushing units is much increased and because also of the cushioning effect of the thick pulp. Balls have the advantage over pebbles that in a unit volume they give more crushing units of a given unit weight. Thus balls can handle thicker pulp and larger tonnages than pebbles.

Some evidence regarding proper length of tube mills is afforded by the experience of the Benguet Consolidated Co.,[2] where two Dewco tube mills grind stamp sands for cyaniding. One mill 6 ft. in diameter and 10 ft. long, run by a 50-hp. motor, takes harder material than the other mill which is 6 by 8 ft. and has a 40-hp. motor. It was thought that the shorter mill would be satisfactory for the softer material, but actually the decrease of 2 ft. in length causes a larger percentage of oversize in the product of the shorter mill. The short mill is driven by 14-in. belt without friction clutch, from a motor with high starting torque, which is not so satisfactory as the friction-clutch drive on the other mill from an ordinary motor which can be brought up to full speed before throwing in the clutch.

These mills have a boltless type of El Oro liner requiring no bolts through the shell. Each circle, 6 in. long, is complete in itself and consists of six segments, four with plain radial ends, and two with plain ends at one extremity and a lug arrangement at the other, whereby, after the circle is in place, it can be expanded tightly against the inside of the shell by means of a 1-in. steel bolt. Steel shims of varying thickness are placed in the plain joints to give better bearings and to adjust the circle. The spaces or pockets in the liner fill with pebbles and this

[1] C. Lindley, Jr., and P. T. Bruhl, *Min. Sci. Press*, **120**, 221, 333 (1920).
[2] C. M. Eye and M. F. Dodd, *Min. Sci. Press*, **121**, 841 (1920).

forms a superior wearing-surface. A No. 5 flint pebble just fits into these spaces. The lining is 5 in. thick with backing of 1 in., thus making the internal diameter of the mill 5 ft. The total weight of liners for the two mills is 10 tons. Ordinary hard white-iron liners last 5 to 7 months and the discarded liner weighs about 55 per cent. of the original. Most of the wear is taken by the pebble filling until the wear of liner has proceeded to the point where the pebbles do not hold in well, when the iron wears more rapidly. When the bolts and lugs are worn off, the set of the pebbles and the fine ore cemented in the crevices hold the liner in place until the back is nearly reached. A ring which wears faster than the others may be replaced with partly worn segments from old liners. It takes 10 hr. to re-line a mill, including the removal of old liners. The end liners each consist of two circles of segments bolted through the heads. Pebbles and hard rock are used for grinding. After a new liner is put in, No. 5 pebbles are fed sufficient to fill the pockets of the lining, and then smaller pebbles (No. 3 and 4) are added in excess of the mine-rock until a good grinding charge is secured. Thereafter, a mixture of mine-rock and flint pebbles in the proportion of 3:1 is added daily as needed, the pebble charge being maintained at 2 in. above the center line of the mill to give the best grinding with lowest power consumption. If the ammeter shows a drop in power consumed with a corresponding increase in the coarseness of the product, the proportion of flint pebbles is increased. Imported pebbles cost $75 per ton as against $2 to $3 for mine-rock which also carries gold and silver values. The mine-rock is not hard enough to serve alone for a grinding medium. No gratings are used at the discharge-ends of these mills, as the reverse spiral liners prevent pebbles and coarse rock from working out.

The changes in the Bonne Terre mill referred to later under *Examples of Practice* involved some tests of crushing machines. The problem was to grind 10 to 2-mm. ore consisting of galena in limestone, so that the product would be largely through 2 mm. A 6-ft. by 22-in. Hardinge conical mill and a 6 by 4-ft. Allis-Chalmers ball granulator run both with and without grates were both tried out on this same feed, and the latter without grates proved the better, not because it showed the higher crushing efficiency, but because it produced the more desirable product for concentration, that is, the highest capacity in tons crushed through a 10-mesh screen, the highest ratio of tons through 10 mesh per horsepower and the lowest percentage of minus-200-mesh material in the finished product. It was found that the speed and ball load determined the power consumed. Variations in speed did not give a marked difference in the work done, over ranges of 420 to 490 ft. per min. peripheral speed for the cylindrical mill and 450 to 550 ft. per min. for the Hardinge.

Variations in ball load were also found to be of minor importance. A heavy ball load means more power but more capacity up to the point where the balls discharge through the trunnion, the amount of crushing per horsepower remaining practically constant. The best combination found for the Hardinge mill was 28 r.p.m. and 10,000 lb. ball load with 51.6 hp.; for the Allis-Chalmers mill with peripheral discharge, 23 r.p.m. and 12,000 lb. ball load with 62.5 hp.; for the same mill with open trunnion, 26 r.p.m. and 12,000 lb. ball load with 69.0 hp.

The size of the balls determined the nature of the product. Balls of 5-in. diameter were necessary to crush the coarse ore; small balls increased the slime. Cast-iron balls broke into pieces of 1-in. diameter or less and caused a gradual increase in the amount of oversize and amount of slime, and were replaced by 5 to 2-in. steel balls. The highest capacity with lowest slime was obtained with a large proportion of 5-in. balls and the present practice is to use an equal area of each size, that is, the 12,000-lb. charge is made up of 5460 lb. of 5-in. balls, 4040 lb. of 4-in. and 2500 lb. of 2½-in., and new balls are added weekly in this ratio. In the Hardinge mill using cast-iron balls in the proportion of 4500 lb. of 2-in., 3300 lb. of 1½-in. and 2200 lb. of 1¼-in., the ball consumption was 1.218 lb. per ton. With steel balls 2½-in. 6000 lb., 2-in. 4000 lb., and 1½-in. 2000 lb., this was reduced to 0.332 lb. per ton, and still further to 0.120 lb. per ton by changing to 4700 lb. of 5-in., 2950 lb. of 4-in. and 2350 lb. of 2½-in. The Allis-Chalmers mill using open trunnion and a charge of steel balls in the proportion of 500 lb. of 5-in., 1500 lb. of 4-in., and 7000 lb. of 2½-in. gave a wear of 0.143 lb. of balls per ton.

The moisture content affected the results mainly in the very fine sizes. Increasing the moisture from 45 to 70 per cent. decreased the capacity of the Hardinge mill about 10 per cent., from 258 to 232 tons, with a corresponding decrease in slime of 33 per cent., from 37.8 per cent. to 25.5 per cent. The amount of 10-mesh oversize did not decrease materially. Similar results were obtained with the Allis-Chalmers mill, but less marked. Present practice is to maintain an average of 60 per cent. moisture.

Plots of the rate of feed against the tons product through 10 mesh and the percentage of slime, the moisture content remaining constant at 60 per cent., showed that higher feed means more tons through 10 mesh and less slimes, which is to be desired. It also means less consumption of balls and liners per ton of ore. The best procedure is to crowd the mill with a feed having high moisture content and to make a large amount of return oversize. The limit of capacity for the peripheral-discharge mill was 340 tons through 10-mesh screen, against 390 tons for the open trunnion and 255 tons for the conical mill. This was one of the

main factors that led to the selection of the open-trunnion mill. With the peripheral discharge, when the 10-mesh oversize amounted to more than 25 per cent., the mill began to fill and finally choked. The following table shows the mill work under best testing conditions and under normal operating conditions respectively, the product containing from 20 to 25 per cent. of 10-mesh oversize for each mill, which has proved to be the most satisfactory in every way. The open-trunnion mill shows the highest capacity and highest tons per horsepower. The Hardinge mill produces more slime lead, and the peripheral discharge gives the largest amount of granular galena, but is ruled out by the mechanical troubles, delays and limitation of capacity due to the grates.

BALL-MILL RESULTS

	Hardinge Mill.	Peripheral-discharge Mill.	Open-trunnion Mill.
Best Test Conditions			
Speed, r.p.m.	28.0	23.0	26.0
Weight of balls, pounds	10,000	12,000	12,000
Size of balls, inches	4–2½	5–4–2½	5–4–2½
Material of balls	Steel	Steel	Steel
Tons of feed per day	370.0	450.0	600.0
Per cent. moisture	59.3	59.5	60.0
Horsepower consumed	51.6	62.5	69.0
Delays, per cent. of time	1.41	6.44	0.70
Capacity, tons through 10 mesh	255.0	340.0	390.0
Tons through 10 mesh per horsepower	4.93	5.45	5.65
Per cent. slime in product	22.7	21.88	17.0
Normal Conditions			
Tons of feed per day	300.0	375.0	450.0
Per cent. moisture	60.0	60.0	60.0
Horsepower	51.6	62.5	69.0
Capacity, tons through 10 mesh	237.0	305.0	345.0
Tons through 10 mesh per horsepower	4.60	4.88	5.00
Per cent. slime in product	28.2	24.2	24.1

Rod Mills.—The Marcy, Cole-Bergman or Allis-Chalmers types represent the biggest development in crushing machinery and give great promise for reducing from breaker size to around 30 mesh, with an indicated saving of about 30 per cent. over ball mills. These mills are beyond the experimental stage. All three types are large, massive machines, well constructed, and find representation in the Phelps Dodge, Iron Cap and Homestake plants.

The Cole-Bergman 5 by 10-ft. rod mills began operation in the Iron Cap mill in June, 1920. These mills have ball bearings. Tests of these mills at Ajo were reported last year in MINERAL INDUSTRY. The oper-

ation at Iron Cap gives an opportunity to make direct comparison with the No. 86½ Marcy ball mills used in the Inspiration mill in making tests on the Iron Cap ore. The detailed flow-sheet of the Iron Cap mill is given later under *Examples of Practice.* In the Inspiration mill the Marcy ball mill handled 300 tons of Iron Cap ore per day using 14.5 kw.-hr. per ton. In the Iron Cap mill the rod mill handles 325 tons to the same fineness of 48 mesh. The Inspiration power consumption per ton from run of mine, including coarse crushing, was 14.96 kw.-hr. against 9.638 kw.-hr. at Iron Cap. The figure for power consumed in the entire Iron Cap mill is 18.68 kw.-hr. per ton against 23.40 kw.-hr. at Inspiration using ball mills on the same ore. Steel balls cost 4 to 5 cts. per lb. at the factory against 2 cts. per lb. for steel rods. Freight brings the cost for balls up to a little over 5 cts. and rods up to 3 cts. in Arizona. The wear of rods and balls is about the same, being 2.8 lb. of steel, including scrap, per ton of Iron Cap ore crushed. The end liners in the rod mill must be high-grade steel. The body liners should be 3 in. thick instead of 2 in. as originally installed, and may be of lower-grade material since rods do not produce pockets like balls and the rod-mill liners wear longer, thinner and more uniformly with less final scrap than ball-mill liners. A liner consumption of 0.75 lb. per ton is expected in the Iron Cap rod mills, giving an advantage of about 25 per cent. over ball-mill liners. The total saving in expense for power, balls and liners at Iron Cap is figured as one-third as compared with ball mills.

A further advantage claimed for rod mills is that flotation concentrates from rod-mill pulp are more granular and filter more quickly and efficiently. Iron Cap flotation concentrates from the Oliver filter contain 11 to 12 per cent. moisture in a cake ½ to ¾ in. thick against 16 to 17 per cent. moisture and a 3/16-in. cake from the flotation concentrates in ball-mill plants in Arizona.

The Marcy roller mill is strongly constructed of steel with manganese-steel nose on the scoop-feeder, ball-and-socket bearings, and large discharge-opening supplied with a hinged plug or door to nearly fill the opening and keep the rods in but allow pulp to discharge. The rods are 3 in. in diameter of 0.6 to 0.8-per cent. carbon steel, and the liners are chilled iron. They are made in sizes 6 ft. in diameter by 12 ft. long, 5 by 10, 4 by 8, and 3 by 6. The 6 by 12 is 5 ft. 6 in. by 12 ft. 1½ in. inside the liners; the shell is 6 ft. 6 in. in diameter inside; the wooden backing for the liners is 2 in. thick and the liners 4 in. thick; the door-opening is 36 in. in diameter, thus giving a 15-in. height of discharge and insuring a low pulp-line. The argument for this low pulp-line, which obtains in the Marcy ball mill as well, is that it allows a thick pulp with 70 to 75 per cent. of solids, and quick discharge. With thick pulp an overflow ball

mill spews out the balls with uncrushed ore and in an overflow rod mill the thick pulp separates the rods so that grinding ceases and big masses of uncrushed material are discharged. The voids in a ball mill figure 46 per cent. and in a rod mill 26 per cent. The rod mill has less internal friction, takes less power, and has less impact action since the rods exert direct pressure on thin layers of thick pulp lying between them. This end point is best obtained by a heavy, slowly revolving rod mass with a low pulp-line.

The Phelps Dodge companies are installing 42 Marcy roller mills, 6 by 12 ft., at Nacozari, Tyrone and Bisbee, all in connection with the Burch flow-sheet in which the primary roller mill receives 1½-in. feed from the Symons disc crusher and grinds it to about 10 mesh. This product is classified into sands going to tables and slimes to flotation. The table tailings after dewatering are reground in a second roller mill operating in closed circuit and the product joins the other slimes going to the flotation feed. In the Bisbee and Nacozari plants the second mill is a Marcy roller mill, but in the Tyrone plant the Marathons are to be used for the second mill because the company had them on hand and did not wish to scrap them. The primary mill at Tyrone treats 1026 tons of feed mostly through 1½ in., uses 150 hp. at 17.5 r.p.m. and gives a product with 8.6 per cent. on 14 mesh and 23.8 per cent. through 200 mesh; 388 tons of the product is minus 48 mesh and the power per ton of feed is 2.62 kw.-hr., or per ton minus 48 mesh, 6.94 kw.-hr. Steel-rod consumption is 1.29 lb. per ton and chilled-iron liners 0.63 lb. per ton. By an increase in the per cent. of solids in the pulp to nearly 78 per cent. the liner consumption has been reduced to 0.5 lb. per ton and the rod consumption to 1 lb. Comparison at Tyrone of roller-mill product, one pass only, with ball-mill product, classified, showed that the Wilfley table gave 10 per cent. higher extraction on the roller-mill product than on the ball-mill product, due to the uniformity of the former with absence of oversize pieces. Experiment on speeds from 15 to 17.5 r.p.m. and on rod loads showed that while the power went down as the speed and size of rod load decreased, it did not warrant the decrease in tonnage, so that 17.5 r.p.m. is now standard for a 6 by 12-ft. mill, and at this speed the rods are close to the cascading point. New rods 3 in. by 12 ft. weigh 290 lb. and the scrapping point is close to ⅝-in. diameter or about a 5 per cent. loss. The cast-iron liners at Tyrone last 4 to 5 months and are remelted in a local foundry with scrap rods to furnish new liners.

At Nacozari the following results were obtained with 6 by 12-ft. Marcy roller mill on hard ore broken to 1½ in.

	Single Pass.	Closed Circuit with Dorr Classifier.
Tons of feed per 24 hr	668.2	276.0
Horsepower	153.3	141.1
R.p.m.	17.5	17.5
Tons of minus-48-mesh product	260.3	229.1
Kw.-hr. per ton fed	4.11	9.16
Kw.-hr. per ton of minus-48-mesh product	10.54	11.03
Rods consumed, pounds per ton	1.80	2.95
Liners consumed, pounds per ton	0.67	0.64
Rod load, tons	19.0	19.0
Per cent. on 48 mesh	49.24(a)	4.5
Per cent. on 65 mesh	7.60	8.2
Per cent. on 100 mesh	6.80	12.0
Per cent. on 150 mesh	4.72	7.8
Per cent. on 200 mesh	4.24	10.7
Per cent. through 200 mesh	27.40	56.8

(a)2.12 per cent. of the products as coarse as 8 mesh.

The No. 86 Marcy ball mill on Nacozari ore under conditions corresponding to the last column treats 320 to 330 tons per day, using 230 hp. and consuming 2.6 lb. of balls and 0.5 lb. of liners per ton. The 1½ years of operation at Nacozari shows an increased efficiency amounting to 32 per cent. for the rod mill over the No. 86 ball mill, including power, labor and wear of rods and liners.

The Denver Engineering Works Co. puts out a rod mill 6 ft. in diameter by 10 ft. long, with scoop feed and open-trunnion discharge, 24 in. in internal diameter. This mill is supported on trunnions at either end, makes 17 r.p.m. and has a short Link-Belt silent chain drive from the motor-shaft to the pinion-gear shaft which drives the mill.

The Allis-Chalmers rod mills used in the Southeastern Missouri lead district employ large rods 5 in. in diameter. These large rods crystallize through the repeated hammering before they wear down small enough to become bent and have to be removed. Full-sized rods are fed as needed and when they wear down to about ½ in. the effect of the crystallization is to cause them to break into short pieces and discharge with the ground ore, thus obviating a shut-down for their removal and ensuring continuous operating of the mill.

Crushing Formulas.—The commonly-used concentration formulas may be used for ball mills to determine the relation of finished product to returns where it is not practicable to measure both of these directly.[1] It is only necessary to make sizing tests of four products.

In the case where the classifier is preceding the ball mill in closed circuit:

x = weight of total original feed to classifier = also classifier overflow.
y = weight of tube-mill feed (classifier sands) = also tube-mill discharge.

[1] G. O. Deshler, *Eng. Min. Jour.*, **109**, 861 (1920).

A = per cent. of finished size in original classifier feed.
B = per cent. of finished size in tube-mill feed.
C = per cent. of finished size in tube-mill discharge.
D = per cent. of finished size in classifier overflow.

Then $Ax + Cy = Dx + By$

or $y = \frac{D - A}{C - B} x$

In the case where the ball mill precedes the classifier in closed circuit:

x = weight of original feed to mill = also classifier overflow.
y = weight of classifier sands = also return to ball mill.
A = per cent. of finished size in original feed.
B = per cent. of finished size in classifier sands.
C = per cent. of finished size in mill discharge.
D = per cent. of finished size in classifier overflow.

Then $C\ (x + y) = By + Dx$

or $y = \frac{D - C}{C - B} x$

Crushing Practice.—The impressions of a stranger on our methods of crushing in the porphyry copper mills form interesting reading.[1] The specially impressive features appeared to be the use of large gyratory breaker with a capacity of 1000 tons per hour crushing to 3 in. followed by high-speed rolls, belt-driven, with steel springs to further reduce to ½ or ¾ in. in two stages with no oversize return. The capacity of four sets of 60-in. rolls working two sets in series is 6000 tons per 24 hr. This coarse crushing is done dry and forms a separate operation with storage-bins between it and the fine wet crushing department. The fine crushing is now almost universally carried on in ball mills of either the cylindrical or conical type.

Ball-mill practice today is departing from the single-stage reduction from breaker product, and is toward finer crushing in rolls to obtain greater capacity at less cost. A feed of 2½-in. maximum size is not as good as 1 in. or even down to ¼ in. In discussing the effect of the crushing resistance of the rock and the proper size of ball, H. Hanson[2] makes six divisions of the methods which may be used, as follows:

1. Breaker and single-stage ball mill.
2. Breaker and two-stage ball mills.
3. Breaker, rolls, and single-stage ball mill.
4. Breaker, rolls, and two-stage ball mills.
5. Breaker, coarse and fine rolls, and single-stage ball mill.
6. Breaker, coarse and fine rolls, and two-stage ball mills.

[1] *Min. Sci. Press*, **121**, 419 (1920).
[2] *Min. Sci. Press*, **120**, 17(1920).

Method 1 is justified only on soft ores or small plants and even then is of doubtful economy and wherever the capacity of the plant requires two grinding machines the two-stage reduction of the breaker product is more elastic and more economical. Large balls, up to 7 in., must be used for hard breaker product. The coarse and fine roll combination is represented by the Alaska Gold mill, which crushes the ball-mill feed to 8 mesh probably more economically than is possible in any other machines. It is true that rolls require more attention than ball mills, but they are more or less fool proof and are elastic as to capacity. The wear of roll-shells is much less than that of balls and liners.

Coarse and fine rolls and two-stage ball mills of method 6 may find best application on very hard ore with fine reduction. To those who are opposed to rolls three-stage ball-mill reduction may be used, employing a primary ball mill of exceptionally heavy construction to receive the breaker product.

It is very interesting to note in this connection that the Inspiration mill no longer feeds large material from the breakers direct to the Marcy ball mills, but reduces it by rolls or Symons disc to ¾ in. and would like to have it down to ½ in.

The Homestake company is adding to its plant a new 1000-ton South mill in place of the old Homestake or "Eighty" mill, which is to be abandoned. The ore crushed in Gates breakers goes into the ore-bin and thence by suspended Challenge feeders to short trommel with ⅜-in. holes delivering an undersize to by-pass the stamps. These are 120 in number, weigh 1550 lb. each, drop 8 in., 100 drops per min., and discharge through a 2 or 3-mesh screen. Heavy stamps were chosen for increased tonnage, compactness in building, lower labor and iron costs in operating and probably some water economy. No mercury is fed to the battery. The stamp pulp with the trommel undersize passes to six diaphragm cones in parallel, selected for quick dewatering. The sand goes to six rod mills and the overflow to the plates later. The rod mills are Allis-Chalmers, six in number, 5 ft. diameter and 10 ft. long. They are preferred to tube mills because of larger units, and because pebbles give poor results in thick pulp with the coarse feed of this high specific gravity (3.00) ore. They are preferred to ball mills because experience elsewhere has shown lower costs. They can be readily changed to ball-pebble mills if rods should prove unsatisfactory. Mercury will be fed to rod mills, and the launders leading from the rod mills to the six Dorr classifiers will be lined with removable, silver-plated, copper plates to catch the coarse gold. The Dorr-classifier discharge returns to the rod mills and the overflow, which is minus 60 or 80 mesh, goes to six amalgamated-plate units of two tables each, 9 by 24 ft. All of the coarse gold is caught

by amalgamation, this arrangement giving about 25 per cent. more gold in the slime than the old Homestake practice; but this is of no consequence because all free gold that will pass a 100-mesh sieve is completely dissolved by cyanide later. From this point on to the cyanide department the flow-sheet is not definitely decided, but at least one unit of diaphragm cone, Dorr classifier, tube mill, and amalgamated plate will be installed to guard against loss through coarse ore passing to the cyanide department from accidental stoppage of the diaphragm cones, etc. This may be expanded further in case it should be found economical to discontinue rod-mill grinding before reaching finished sizes, and make the final reduction in tubes.

The new coarse-crushing plant of the Miami Copper Co. is nearing completion and promises to be a big step in the crushing of ores to medium fineness, so that its actual operation is awaited with much interest.

The crushing system of the Shattuck-Arizona mill, described later under *Examples of Practice*, is a result of careful study of the ore. Gyratory breakers, crushing to 1.5 in., are followed by rolls to $\frac{5}{8}$ in. The roll product is sized into material $\frac{5}{8}$ in. to 4 mm. and undersize of 4 mm. The latter represents the softer carbonate material and is tabled, and the table tailings reground in a 4 by 10-ft. Allis-Chalmers ball-tube mill in closed circuit with drag classifier, making a final product with 32 per cent. through 200 mesh. The oversize of the 4-mm. screen is hard silicious material and is ground direct in two 6 by 4½-ft. Marcy ball mills in closed circuit with Dorr classifiers, making a final product with 55 per cent. through 200 mesh. The products of the Allis-Chalmers mills and the Marcy mills are mixed and go to tables and flotation.

Sizing at 4 mm., besides providing a rich undersize for tabling and eliminating wear of table-riffles and linoleum by the coarse particles of the oversize which is not tabled, also has the advantage of giving virtually a modified two-stage grinding. The material over 4 mm. is ground in large-diameter ball mills with larger steel balls, heavy ball charges and a high percentage of solids, while material under 4 mm. is ground in a smaller-diameter mill using small cast balls and cheaper cast-iron liners. The new balls charged to the Marcy mills are 85 per cent. 4-in. and 15 per cent. 3-in. forged steel balls, and when the occasion offers the worn balls smaller than 2-in. are sorted out and fed into the tube mill, which is regularly charged with 2-in. and 1.5-in. cast balls, although a small percentage of 3-in. balls appears to give the mill more grinding capacity. The tube mill makes 31 r.p.m. and the ball mills 25 and 23½ r.p.m.

In the new Sunnyside mill, in Colorado,[1] the ore from the breakers goes to three 8 by 6-ft. Marcy ball mills in closed circuit with Dorr

[1] *Eng. Min. Jour.*, **109**, 838 (1920).

classifiers. Each mill crushes 400 tons in 24 hr. through 28 mesh, using rhodochrosite from the mine as pebbles. Further comminution is obtained by three 4 by 15-ft. and two 5 by 14-ft. tube mills, each in closed circuit with a 6-ft. Dorr classifier. Seventy per cent. of the final pulp is minus 200 mesh.

The New Modderfontein gold mill represents the latest South African practice in crushing and sorting.[1] The mine ore goes to three washing and sizing trommels 5 ft. in diameter, 20 ft. long, sloping 10° and making 10 r.p.m. The holes are 3 in. by 1.5 in. These trommels insure a thorough washing of the oversize before it passes to three picking belts 3 ft. wide, 88 ft. long and running at a speed of 40 ft. per min. The waste which is sorted out goes to the dump, while the ore is crushed to about 1.5 in. in four No. 6K Gates gyratory breakers, except that one gyratory is set coarser to deliver the lumps used in the tube mills instead of pebbles. The undersize of the trommels goes to three sizing trommels 5 ft. in diameter and 12 ft. long with 3-mesh aperture, being the same size as the Nissen-stamp screen. The oversize joins the gyratory breaker product going to the Nissen stamps, while the undersize by-passes the stamps and goes to the tube mills. There are 50 Nissen stamps weighing 2000 lb. each and having fluted roller feeders. Each stamp crushes 30 tons per 24 hr. through a 3-mesh screen, the product going to the tube mills, of which there are eight, each 6 by 20 ½ ft., fitted with 5-ft. diameter Schmitt feeders, Osborne liners and scoop-discharges, and a ball compartment can be put in if desired. They run at 28 r.p.m. and deliver pulp to classifying cones followed by amalgamating plates and traps and a second set of classifying cones which return sand to the tube mills for regrinding. The fine pulp passes on to the cyanide department.

The noteworthy features of this mill are the thorough washing before sorting, the use of Nissen stamps, the possibility of compartmenting the tube mill for balls and the gravity flow of ore and pulp.

The reader is also referred to the work of crushing machines as amalgamators later under *Amalgamation*.

Screening, Classifying, and Settling

Screens.—Nothing but success is reported for the new vibrating screens of the Mitchell and Hummer types. The Hummer has added a weighted distributing gate at the head. The following performances are recorded for a double 6-ft. Hummer with 30 sq. ft. of screening area: 200 tons of Missouri lead ore per hour at ⅜ in., replacing two trommels 3½ by 12 ft.; over 100 tons of coal per hour at ¼ in., making 50 per cent. undersize; Arizona Copper Co., 2100 tons per 24 hr. at 4 mesh at a

[1] E. M. Weston, *Eng. Min. Jour.*, **109**, 255 (1920). *Min. Sci. Press*, **120**, 780, 789 (1920).

cost of 0.148 cts. per ton; zinc dust, 2 tons per hr. at 200 mesh with 99½ per cent. of undersize. It is also finding an extensive field on clay, cement, etc. In the case of dry grinding of cement in ball mills its efficient screening is making it very popular because the better the screening the less the amount of oversize to be returned for further grinding, and the grinding capacity and efficiency is thereby increased.

Another vibrating screen has appeared, being manufactured by Overstrom and Sons. An unbalanced pulley on a fixed shaft imparts 3000 vibrations per minute to the screen frame through four spiral springs. The screen motion is elliptical, with a variable amplitude of 1/32 to 3/16 in.

The Cole screen is a gently sloping screen-frame about 4 ft. square which is apparently supported and vibrated in such a manner as to impart to the screen a combined vertical and horizontal motion which resembles the motion of the Ferraris screen. Results are reported from a test where the feed was moist ore crushed through a 1¼-in. round hole. The screen was 2½-mesh wire cloth (¼-in. hole) and handled 87.5 tons per hr., delivering 60 per cent. as undersize with a screening efficiency of 96 per cent. The speed of the machine was 470 r.p.m.

A new fixed inclined screen called the Wullstein Gravitation screen is being developed by the United Filters Corporation. It has a series of toothed bars which are placed in units on an incline to form the screening surface.

Dorr Washer.—This was mentioned last year as a Hydroseparator. An installation on iron ore at the Mariska mine, Minnesota, makes products as follows:

	Weight, Per Cent.	Iron, Per Cent.	Silica, Per Cent.	Phosphorus, Per Cent.	Per Cent. of Total Iron.
Feed	100.00	55.00	15.30	0.062	100.00
Trommel oversize	43.03	59.42	7.73	.....	46.49
Rake product	42.90	57.62	8.47	.....	44.94
Total concentrates	85.93	58.52	8.10	0.070	91.43
Tailings	14.07	33.50	.....	.....	8.57

Classifiers.—The tendency is to employ the heavy Dorr Model D type where large tonnages are to be handled, especially in closed-circuit grinding. The Dorr Bowl classifier is used where highest efficiency is desired, since in closed-circuit grinding it makes a better finished product and better elimination of undersize from the product returned to the grinding mill. Several installations have been made in Mexico; the largest bowl classifier to date is the 19-ft. bowl in a Model D classifier for dewatering tailings in the magnetic concentrating mill at Lebanon, Pa.

A new installation is that of two classifiers with 15-ft. bowls in the regrinding plant of the Nipissing mill. Sizing tests are as follows:

	Tube-mill Feed, Per Cent.	Bowl-classifier Feed, Per Cent.	Finished Product, Per Cent.
On 200 mesh	38.5	5.3	0.1
Through 200 mesh, sand	54.0	29.5	13.0
Through 200 mesh, slime	7.5	65.2	86.9

Before the introduction of the bowl classifiers the finished product on 200 mesh averaged about 6 per cent. The new arrangement has eliminated the picking plant, has increased the recovery of silver about 1 oz. per ton or to over 95 per cent., with a material saving in the cost of treatment since the high-grade ore is not picked out, but is treated with the low-grade.

In the new Homestake plant diaphragm cones are retained as affording the simplest and cheapest means of connecting with existing equipment in cyanide plant. If the entire treatment plant were being redesigned Dorr Bowl classifiers would be installed as the most efficient machines.

A simple drag classifier made on the spot at the Benguet Consolidated mine has a wooden tank 26 in. wide and 14 ft. long. The sloping bottom gives a depth of 24 in. at the lower end. The belt is five-ply balata, 8 in. wide, with flights of 2-in. angle-iron bolted to it at 12-in. intervals, and runs over a head pulley 16 in. in diameter and a tail pulley 26 in. in diameter. It is driven at a speed of 28 ft. per min. by a belt and spur gear to the head pulley. Every fourth flight is 22 in. long, while the rest are 18 in. This yields a sand product with less moisture than if the flights were of equal length.

Thickeners and Settlers.—The tray types of Dorr thickeners are being more extensively used for dewatering flotation concentrates and are gaining favor over the non-tray type on account of the saving of space and cost and the simplicity of operation. Four closed-type 40-ft. thickeners with three trays have been installed in the Calumet and Hecla flotation plant. Tray thickeners are in successful use in 50-ft. tanks with three trays, and 75-ft. one-tray thickeners have been built. Thickeners are replacing tailings ponds; they are used in the Anaconda phosphate plant, and are finding application in the form of the "precipitating thickener" for precipitating copper from solution by iron in copper leaching plants. Their work on coal is described later under *Coal Washing.*

For dewatering table and flotation concentrates at the Belmont Shawmut mill three 28 by 7-ft. tanks are filled in rotation. They are fitted with a filter bottom composed of a 2-in. layer of rock crushed to ¼ in. above one thickness of cocoa matting. When a tank is full it drains for 12 hr. and is then further dried down to 3 per cent. moisture by a

vacuum pump, and finally discharged through a hole in the center by means of a 27-ft. Blaisdell excavator.[1]

A similar arrangement is used at the Old Dominion mill at Globe. At the Magma mill Wilfley roughing-table concentrates are dewatered to 5 per cent. moisture in an ordinary Akins classifier arranged over a bin into which it discharges. In the Utah Copper mill table and vanner concentrates are dewatered in Dorr classifiers equipped with filter bottoms made of wire screen, canvas and burlap, under which a slight suction is maintained.[2]

H. Hanson has dealt with thickeners and decanting appliances including intermittent South African practice and continuous American practice in the gold-mill field,[3] and has also written especially on the Dorr Bowl classifier.[4] He makes the point that its high efficiency is due to the greater length of quiet overflow lip as compared with the ordinary Dorr rake form.

Settling problems, including intermittent and continuous work and covering both the clarifying and thickening divisions, have been discussed very fully by W. A. Deane.[5] He deals especially with fine sedimentation, taking up the effects of gas bubbles, heat, flocculation, electrolytes, colloids and channeling. He divides the field into suspensions down to 0.0001 mm., colloidal solutions 0.0001 to 0.000001 mm., and true solutions below 0.000001 mm. For clarification the formula is

$$A = \frac{4(F - D)}{3Sp \times R}$$

where A represents unit settling area in square feet per ton of solids per 24 hr.

R represents settling rate in feet per hour.

Sp represents specific gravity of liquid.

F represents ratio of liquid to solids in feed.

D represents ratio of liquid to solids in discharge.

For thickening the formula is

$$V = \frac{4T(G - Sp)}{3G(S - Sp)}$$

where V represents volume in cubic feet required for thickening per ton of solids per 24 hr.

S represents average specific gravity of thickened pulp.

Sp represents average specific gravity of solution.

G represents average specific gravity of solids in pulp.

T represents period of detention in hours.

[1] A. B. Parsons, *Min. Sci. Press*, **121**, 659 (1920).
[2] *Eng. Min. Jour.*, **110**, 404 (1920).
[3] *Eng. Min. Jour.*, **109**, 853 (1920).
[4] *Min. Sci. Press*, **120**, 905 (1920).
[5] *Trans. Am. Electrochem. Soc.*, **37**, 71 (1920).

Theory.—A study of the efficiency of classifiers by C. D. Demond has demonstrated that cone classifiers consistently do poor work owing to uneven distribution of rising current and tendency for solids to accumulate at the side and slide down, and that no classifier can do perfect work because its action is not positive. By experiment Demond showed that any given group of sized ore grains will not settle twice in the same order. This is an important point which has not been fully appreciated. The Hyde form of classifier described in MINERAL INDUSTRY, **26** (1917), which was based on the principle of settling in still water, looked attractive at first, but was found not to do good work for the above reason. Sizing of the products may not always prove to give a correct index of classifier efficiency.

The fall of particles in a liquid has been discussed mathematically by K. Kegel.[1] He deals especially with particles falling in small channels where the space between the particle and the inner wall of the channel is so small that the descending particle displaces water upward, thus creating sufficient friction to slow down appreciably the falling velocity of the particle in direct proportion to the decrease in ratio of the area of cross-section of the channel to the area of cross-section of the particle. This offers an explanation of the well-known phenomenon that under hindered settling conditions as in a jig bed with a mixture of small heavy particles and large light particles, the small heavy particles descend relatively faster, or perhaps more strictly speaking the large light particles descend relatively slower than under free settling conditions where the same mixture of particles fall independently and sufficiently far apart as to avoid any hindering effect of the channels in which they fall.

HAND SORTING, JIGS AND TABLES

Sorting.—The sorting practice at the New Modderfontein mill has been already discussed under *Crushing*.

Jigs and Tables.—In the remodeled Arizona Hercules mill the double jigs are constructed of concrete.[2]

In the latest design of Wilfley table an enclosed self-oiling head motion is used and the spring, formerly under the table, now works with the other parts of the head motion in the enclosure. The draw-bar is arranged so that it can be quickly disconnected.

Some rather indecisive results from tests of wood and fluted glass surfaces on fixed inclined tables treating tin ore at Porco, Bolivia, seemed to indicate that glass gave a higher extraction but lower grade of concen-

[1] *Metall und Erz*, **24**, 535 (1920).
[2] J. T. Shimmin, *Eng. Min. Jour.*, **109**, 1115 (1920).

trate. However, a Deister slimer gave a much higher-grade concentrate with about the same recovery as the glass surface.[1]

Millmen are considering the question of the relative merits of jigs and tables and also the possibility of eliminating jigs in some cases and simplifying the mill by using finer crushing. The abandoning of jigging through the discard of the Hancock jigs in the Bonne Terre mill, described later under *Examples of Practice*, is an example of how one company has worked it out.

In the Lake Superior native-copper district the Quincy and Copper Range companies have conducted experiments on substituting tables for jigs on 3/16 to 1/4-in. material, and as a result the Copper Range Co. has one complete stamp unit now operating without any jigs. The tables on the coarser sizes make only finished concentrates, the tailings being reground in ball mills. The claim of this company is that on their comparatively rich ore the copper can be saved more advantageously by a Wilfley table than from a jig bed. The Quincy people say that on their ore the table works just as efficiently as the jig and the main point is the relative cost, especially the wear of table-tops and riffles by the coarse feed. On Deister tables with coarse-sand feed, wood riffles and the linoleum in the coarse-sand zone last 2 to 3 months and the whole table surface has to be replaced every 6 months. A deck and riffles of soft rubber, in sections 4 ft. long, and costing $125.00, has a life of about 18 months in the coarse-sand zone and almost unlimited life in the fine-sand zone.

Amalgamation, Magnetic, Pneumatic, and Centrifugal Processes

Amalgamation.—The loss of mercury has been reduced in the New Gooch gold mill[2] by the substitution of corduroy for amalgamated plates. Formerly the loss was 0.1 oz. per ton crushed or 0.7 oz. per oz. of gold recovered. The plate area was too large for ore assaying 0.25 oz. gold per ton. The mill plates have been entirely removed and 23 sq. ft. of corduroy per five stamps substituted in their place. There is also a piece of corduroy of 10 sq. ft. area at the lower end of each tube-mill plate. The corduroy is washed every 12 hours and renewed every six weeks, the cost of 74.5 sq. yd. used annually being 0.04 cts. per ton. The water to ore ratio is 7:1. The mercury loss has been reduced 0.04 oz. per ton or 0.3 oz. per oz. of gold recovered. The corduroy washings are amalgamated in a clean-up barrel with mercury and a water to ore ratio of 1.5:1. The mercury loss is still further reduced by cleaning the tube-mill plates only once in 8 hr. instead of 4 hr. as formerly. There is a

[1] H. A. Lewis, *Inst. Min. Met.*, **27**, 71 (1919).
[2] H. J. Lee, *Jour. Chem. Met. Min. Soc. So. Afr.*, **20**, 139 (1920). *Mining Mag.*, **22** 375 (1920).

possibility of discarding plates entirely for corduroy with reduction of mercury loss to not over 0.01 oz. per ton and without any sacrifice in the amount of gold recovered by amalgamation.

This whole question of losses of mercury in amalgamation, with proposed substitution of other processes, has been discussed in a comprehensive paper by E. M. Weston,[1] who deals with the theory of amalgamation and the causes of losses of gold and mercury in the process. He suggests that stationary riffle tables or concentrating machines may be substituted to advantage and cites a few examples of where this has been done successfully. While his ideas sound attractive it seems doubtful whether any other process will economically displace amalgamation. Incidentally he disapproves strongly of adding mercury to a tube mill.

Successful amalgamation in tube mill is done at the Gold Hill mill, Quartzburg, Ida.[2] The ore is an antimonial gold-bearing ore, the gold being fine and requiring scouring in order to amalgamate readily. The best that could be done by stamps was 55 per cent. recovery. The ore is now ground in a Hardinge mill running with thin pulp and at the low speed of 18 r.p.m. in order to cause the pebbles to slide instead of cascade. Mercury containing sodium is added in the scoop of the mill and the ground pulp flows through a circular amalgamated plate attached to the discharge trunnion, having longitudinal riffles, and then through stationary amalgam traps and over fixed amalgamated plates, and finally to Overstrom tables which make concentrates going to the cyanide plant. The total recovery is 85 per cent. of the gold. Iron balls in the Hardinge mill gave poor amalgamation, which seems to bear out the theory of the necessity of scouring the gold rather than pounding it.

V. A. Stout[3] has likewise reported the results at the Plymouth Consolidated mill, where an average recovery of 71 per cent. of the gold was obtained by amalgamation, using Hardinge patent amalgamators on the discharge-end of the Hardinge mill, followed by riffles similar to those used in placer mining, then lip-plates, then amalgam traps, and finally stationary plates. Where the gold is bright it is not dvisable to feed mercury into the Hardinge mill. He advocates the use of sufficient amalgamating devices to ensure efficient recovery.

The history of amalgamation at the La Luz and Los Angeles mine in Nicaragua[4] gives comparison of various crushing machines as amalgamators. Originally on the soft oxidized surface ore Huntington mills did good work but failed to crush the harder ore met with at depth. Later ten stamps with No. 421 Toncap screens worked all right. A

[1] *Jour. Chem. Met. Min. Soc. So. Afr.*, **20**, 131, 160; **21**, 63 (1920). *Mining Mag.*, **22**, 375 (1920).
[2] E. E. Carter, *Eng. Min. Jour.*, **110**, 983 (1920).
[3] *Eng. Min. Jour.*, **110**, 394 (1920).
[4] J. Scobey, *Eng. Min. Jour.*, **110**, 6 (1920).

Hardinge 6-ft. ball mill in competition with stamps was not satisfactory, but by using the ten stamps to crush to 4 mesh followed by an 8-ft. by 36-in. Hardinge pebble mill with an Akins classifier ahead of the pebble mill, the results were all right, the tonnage being 80 to 90 tons of hard ore for 24 hr. When running ten stamps followed in part by one 6-ft. Hardinge ball mill at 27 r.p.m. and in part by two 8-ft. Hardinge pebble mills at 26 r.p.m., the power required was beyond the ability of the power-plant to supply, but by reducing the speed to 20 r.p.m. the power was reduced with no loss in tonnage. An attempt to use scrap iron in place of balls in the ball mill was not satisfactory on account of decreased capacity. In the pebble mills hard auriferous blocks of mine-ore are used successfully, amounting to 4.3 per cent. of the total ore ground. The recovery by amalgamation over a period of 19 years has averaged 66 per cent., running as high as 77 per cent. in one year with the Huntington mills and as low as 60 per cent. in one year with the stamps and Hardinge mills; but, considering the variability of the ore, the manager considers that the ore is ground for amalgamation just as satisfactorily in the Hardinge mills as in Huntington mills or in stamps.

The feeding of mercury to rod mills and the use of amalgamated plates in the new Homestake unit has been described under *Crushing*.

A. Del Mar has reported successful amalgamation at the Rosamarada mill in flotation circuit on an ore carring free gold with sulphides of lead, copper and silver. The copper rules out cyaniding; flotation saves the sulphides, but about 25 per cent. of the free gold escapes. Amalgamated plates are therefore used between the classifier and flotation machines after grinding the ore with crude oil in the ball mill, and more plates are used after the flotation machines where pine oil has been added for flotation. The plates are reported as bright and clean and showing no traces of oil or fouling of any nature.

Magnetic Concentration.—A new development in iron-ore concentration in New Jersey is the Replogle mill on the rehabilitated Wharton property, where dry magnetic concentration is used to save the magnetite and is followed by wet tables to save the martite. The mill treats about 80 tons per day of ore assaying 36 per cent. iron and makes about 40 tons of concentrates containing 0.057 per cent. phosphorus, 60.18 per cent. iron and 12.07 per cent. silica. The ore is dried and crushed to 1½ in. by jaw and horizontal-disc crushers and then sized at 1⅛ and 5/16 in. Oversize of 1⅛ in. goes over a magnetic-drum cobber to eliminate tails as waste and make concentrates to be crushed in rolls and join the other sizes which go direct to vertical-disc crushers which crush the ore through 3 mesh. The crushed ore is sized at 3/16 and 5/32 in. and runs over double-belt magnetic separators which make magnetic concentrates to shipping

bin. Fine tails go direct to the wet mill while coarse tails are reground in rolls to 7 mesh and separated on belt and drum magnets into concentrates to market and tailings which join the fine tailings going to the wet mill. In the wet mill the material is classified and the sand goes to Wilfley table and the slime to Deister slime table. The latter makes concentrates and tailings while the former makes also a middling product which is cleaned up on a Deister sand table. All final wet concentrates and tailings are dewatered in drag classifiers.[1]

The experimental work on the Eastern Mesabi finely disseminated magnetite ores, described in MINERAL INDUSTRY, **27,** 803 (1918), has now reached the point where after an expenditure of nearly $800,000 the first unit of a final 22-unit plant is under construction and is expected to be operating by the fall of 1921. This unit is estimated to cost $3,000,000, and to treat 2000 to 3000 tons of crude ore per day, making 1 ton of concentrates from 2½ tons of ore. If this is a commercial success it will mean the final erection of the entire 22 units costing $60,000,000 and treating possibly 100,000 tons daily. The steps in the process are: 48 by 72-in. jaw-breaker crushing to 12 in.; 36 by 54-in. jaw-breaker crushing to 5 in.; four gyratory breakers crushing to 2 in.; dry magnetic-drum cobbers working in connection with sets of 72 by 20-in. rolls to reduce to ⅛ in. and discard 50 per cent. of the material as waste; ball mills to 100 mesh; magnetic log-washer to make finished concentrates; sintering plant for concentrates.

The magnetic log-washer is a development of the experimental work on this ore. It is similar to an ordinary log washer with the exception that to the bottom of the tank is attached a series of magnets which hold the magnetic material to the bottom of the trough where the action of the logs forces it up the slope and delivers it as a clean concentrate. The machine is very simple and cheap to operate and the wear on the conveyors is much less than in ordinary log-washers, due to the fineness of the ore. It does its best work on material finer than 100 mesh and is not satisfactory on feed coarser than 48 mesh. For the Mesabi Iron Co. each machine is 18 ft. long and 6 ft. wide and contains four spiral conveyors each 18 in. in diameter and making 28 r.p.m., to act as logs. Copper and manganese steel are to be tried as material for these spirals. A capacity of 200 to 300 tons of crude ore per day is obtained when working on material through 150 mesh and making clean concentrates.

The wet magnetic plant at the Sullivan mine at Trail, described in MINERAL INDUSTRY, **28,** 769 (1919), was closed down in June, not because it was not commercially feasible, but because the flotation plant described later under *Flotation* had been developed to the point where it was yield-

[1] A. H. Hubbell, *Eng. Min. Jour.*, **110,** 658 (1920).

ing better results than could ever be hoped for from magnetic treatment, even though the magnetic tailings were tabled to separate the galena from the blende. Perhaps one factor that contributed to the choice of flotation was the gradual change in the character of the ore. In the upper levels the iron sulphide was mostly in the form of weakly-magnetic pyrrhotite with little non-magnetic pyrite, but it is understood that the pyrite increased somewhat with depth and this pyrite was not removed by the magnets.

Pneumatic Separation.—A new dry concentrator named the Cottrell is in the form of a fast-motion table, the motion being similarto that of the Ferraris screen. It is being tried out at Greaterville, Ariz.

Centrifugal Separation.—The Eccleston centrifugal concentrator is still in the testing stage at the Miami mill by the U. S. Bureau of Mines, but they are not yet ready to give out any statement.

Flotation

General.—Perhaps the greatest advance has been made on coal, especially in Europe. This is referred to later under *Coal Washing.* Flotation pulp is being more carefully prepared, with a tendency toward coarser crushing, more cleaning of the concentrates and regrinding of middlings before re-flotation. Unnecessary slime is to be avoided as in gravity concentration. Some progress is to be noted in selective flotation and in the flotation of oxides, particularly oxides of tin and silver. There is a good field for progress in these lines.

The U. S. Bureau of Mines reports that in 1919 flotation handled 26,545,564 tons of ore yielding 3,105,343 tons of concentrates and using 113,510,234 lb. of reagents, or 4.2384 lb. per ton of ore.

Application.—The new 1800-ton leaching and flotation plant for treating the Tamarack conglomerate tailings from native copper ore at Lake Superior is under construction. Flotation has found no place on native copper amygdaloid tailings dumps, as a good recovery can be made from these by gravity methods using jigs for sizes over $\frac{1}{8}$ in. and classifier and tables for stuff under $\frac{1}{8}$ in.

The construction of a mill to treat sulphide ores of the New Cornelia Co. at Ajo, Ariz., has been held up by low copper prices, but the test mill results were satisfactory in giving an extraction of about 85 per cent. of the copper in a concentrate assaying 16.8 per cent. copper. The flow-sheet is along the line of Inspiration practice, crushing to 48 mesh or finer in rod or ball mills, floating in Inspiration pneumatic roughing and cleaning cells of reinforced concrete and running the sand tailings over Deister Plat-O tables. Plateaus $\frac{3}{8}$ in. high gave better results than those $\frac{1}{4}$ in.

in that they were less susceptible to changes of feed. Plain riffles gave as good results as corrugated riffles.[1]

The flotation of Oregon quicksilver ores is successfully accomplished by using fine grinding, light oils and dilute pulp made slightly alkaline with lime.[2]

In the case of gold ores the applicability of flotation depends much on the character of the ore. Minerals Separation plants on a commercial scale are under erection at two important gold mines.

Flotation tests on free gold ore at the La Luz and Los Angeles mine in Nicaragua showed a very low recovery as compared with amalgamation.[3]

Concentration of graphite by flotation at Ticonderoga, N. Y., is accomplished by grinding in Hardinge mills, floating in primary Callow cells, regrinding the concentrates and re-floating in two first cleaner Callow cells in series and finally regrinding these concentrates and floating in two second cleaner Callow cells. All cleaner tailings are returned to the primary cells. This repeated treatment is necessary to obtain the high-grade product required for market.[4]

The Trent process[5] is still under investigation by the U. S. Bureau of Mines and the latest report is of successful flotation of graphite, both flake and amorphous. Light volatile liquids, benzene, toluene and carbon tetrachloride, are better adapted to the cleaning of graphite by this process than oil.[6]

Oxide Ores.—Oxidized silver ores are now being treated successfully in some districts by flotation.

The flotation of cassiterite is possible, but the difficulty seems to be in getting a flotation agent which will raise it without lifting undue proportions of silica and silicates. Tin smelting requires a clean concentrate—much cleaner than in copper smelting, for example.

The Minerals Separation has conducted experiments at several properties in Cornwall and has at present a 30-ton experimental plant at South Crofty. The East Pool Co. has worked independently with fairly good results.

The best results on tin ore have been obtained in mechanical aeration machines, with soap as a frothing agent, the hard water being first softened with soda.

The Minerals Separation Co. reports that the Bwana M'Kubwa oxidized copper deposits in Rhodesia have been thoroughly tested by

[1] C. A. Mette, *Eng. Min. Jour.*, **109**, 1314 (1920).
[2] E. G. Stowell and W. H. Coghill, *Min. Sci. Press*, **120**, 117 (1920).
[3] J. Scobey, *Eng. Min. Jour.*, **110**, 6 (1920).
[4] C. E. Chaffin, *Min. Sci. Press*, **120**, 567 (1920).
[5] Mineral Industry, **28**, 772 (1919).
[6] W. C. Ratliff and J. D. Davis, *Chem. Met. Eng.*, **23**, 1027 (1920).

flotation. A 100-ton plant has treated 5000 tons of crude ore assaying 4 to 5 per cent. copper, of which 90 per cent. is in the form of silicate and carbonate of copper, and obtained an average recovery of 78 per cent. in a 28-per cent. copper concentrate.[1]

Mixed Sulphides and Oxides.—The various copper companies in Arizona report considerable advance toward the solution of this problem. The flow-sheet is not the same with all companies, but in general the ore is first crushed to ¼ in. and leached with sulphuric acid, the copper being precipitated from solution by scrap iron, sponge iron, electrolysis or sulphur dioxide under high pressure at 150°C., obtained by the use of live steam. This last method, developed by Laist at Anaconda, is particularly attractive in that it seems to be as cheap as the electrolytic method and can handle impure solutions without difficulty. The tailings from leaching are ground in ball or rod mills to 48 mesh and treated by flotation to recover the sulphide copper. Experimental work at Inspiration indicates a total extraction of 80 to 85 per cent. by the dual process from ore assaying 1.25 per cent. copper.

The companies that have calcite to contend with are experimenting with sulphur dioxide as a solvent for oxidized copper minerals. As this gas is harmful to flotation it has to be removed by blowing air through the pulp before the sulphide copper can be floated. In some cases the sulphide copper will be floated in the presence of the copper-sulphate solution, and after flotation the separation of the solids and liquids in the flotation tails will be followed by the precipitation of the copper from solution by one of the methods mentioned in the preceding paragraph. In other cases the entire pulp after sulphur-dioxide leaching and aeration will be treated with sponge iron to precipitate the copper and the cement copper and sulphide copper will be finally floated in one operation.

The work of the experimental plant of the Arizona Copper Co. for recovering copper from old partly oxidized tailings by leaching and flotation has been described by A. Crowfoot and K. H. Donaldson.[2]

The tendency toward the development of combined leaching and flotation of mixed copper ores appears to indicate that the sulphidizing of oxidized copper minerals and their subsequent flotation is not considered a commercial success by Arizona operators.

Selective Flotation.—Considerable progress has been made along this line. The experiments mentioned last year[3] on the heavy copper and iron sulphide ore of Bingham, Utah, were continued in a 50-ton experimental plant so successfully that a 1000-ton mill has been built and will be operated when the copper market improves. The flow-sheet has

[1] W. Broadbridge, *Eng. Min. Jour.*, **109**, 784 (1920).
[2] *Eng. Min. Jour.*, **110**, 471 (1920).
[3] MINERAL INDUSTRY, **28**, 773 (1919).

direct crushing with ball and tube mills to 85 per cent. through 100 mesh, followed by pneumatic flotation in Callow cells using X-cake and Xylidin in an alkaline circuit. The copper recovery is expected to be around 90 per cent. in a concentrate assaying 13 per cent. copper and 23 per cent. iron, from an ore assaying 2 per cent. copper and 23 per cent. iron, with a concentration ratio of 5 or 6 tons into 1.

Flotation of the Sullivan ore at Trail, B. C., has displaced magnetic separation as previously noted. This ore is an intimate mixture of lead, zinc and iron sulphides with only 3 to 6 per cent. insoluble, and requires very fine crushing to unlock the values. In August, 1920, the flotation plant was treating 800 tons per day, using the following process. The ore was crushed to 20 mesh and run over Wilfley tables to remove the lead. The Wilfley tailings were ground in ball mills to 170 mesh, only 3 per cent. remaining on 100 mesh and 80 per cent. passing 200 mesh, and then the blende floated away from the pyrrhotite and pyrite in modified Minerals Separation machines using 1 to 1¼ lb. of mixed pine oil and creosote per ton in a pulp made slightly alkaline with caustic soda. Minerals Separation flotation was also applied to the tailings from the electrolytic zinc plant to recover any zinc sulphide which had not been completely roasted.[1] Later this scheme was modified to omit the preliminary Wilfley treatment and float a mixed lead-zinc concentrate which was tabled to recover about 20 per cent. of the lead as a high-grade concentrate. It is now reported that, without the use of any tables whatever, the lead and zinc are floated preferentially, making in a primary flotation a lead concentrate running 45 to 50 per cent. lead and containing 60 to 65 per cent. of the lead values, and a zinc concentrate assaying 35 per cent. zinc and containing 80 per cent. of the zinc values. By installing cleaning flotation machines it is possible to raise the grade of the zinc concentrates to 42 to 45 per cent. with practically the same recovery of the lead and zinc and no reduction in the grade of the lead concentrates, and it is expected that further refinements will lead to the recovery of three products which will contain approximately 80 per cent. of the lead, 80 per cent. of the zinc, and 80 per cent. of the iron respectively. The final tailings contain the iron with not over 0.5 per cent. lead and 2.5 to 3 per cent. zinc. Tables may be still used on the zinc concentrate to take out additional lead and serve as a pilot. The Horwood roasting flotation process was tried at one stage of the development, but although it gave a good separation it was not economical.

Flotation alone on low-grade gold sulphide Rossland ore is found to give better results than can be obtained by tables and flotation.

Elaborate differential flotation tests have been made by the U. S.

[1] F. H. Mason, *Min. Sci. Press*, **120**, 863 (1920). *Mining Mag.*, **22**, 350 (1920).

Bureau of Mines on Idaho lead-zinc ores, a chalcopyrite-pyrrhotite copper ore, a gold and silver-bearing copper ore and an antimonial silver ore.[1] The conclusions are that by using proper reagents and conditions, very good separations are possible, probably better than can be obtained by gravity or other methods. The complete report forms a valuable book of reference for any one interested in differential flotation.

The Minerals Separation report a good separation of lead and zinc sulphides by the use of organic floating agents, obtaining a 60-per cent. lead concentrate containing 80 per cent. of the lead and a 40 to 50-per cent. zinc concentrate containing 85 to 90 per cent. of the zinc.

Minerals Separation tests on ore from the Simon Silver-Lead Mines Co., Nevada, assaying 6.46 oz. silver per ton, 9.1 per cent. lead, 9.2 zinc and 6.5 per cent. iron, gave lead concentrates assaying 39.0 oz. silver, 67.6 per cent. lead, 9.6 zinc, 2.8 iron and 2.0 per cent. insoluble. The zinc concentrates assayed 8.2 oz. silver, 3.2 per cent. lead, 46.8 zinc, 9.0 iron and 2.6 per cent. insoluble, while the tailings assayed 0.54 oz. silver, trace of lead, 1.6 per cent. zinc and 5.7 per cent. iron. The silver in the lead product was 76.1 per cent. of the silver in the original ore.[2]

Preferential flotation at the 500-ton Sunnyside mill in Colorado on a complex ore carrying 0.15 oz. of gold and 7 oz. of silver per ton, 7 per cent. lead, 0.60 copper, 9 zinc and 3 per cent. iron, in a gangue of quartz and rhodonite, is carried out in Minerals Separation machines. The ore is crushed in ball mills and pebble mills so that 70 per cent. passes 200 mesh. Three sets of flotation machines are used, the first ten of 24-in. standard Minerals Separation cells, then six 18-in. subaeration cells, and finally twenty 24-in. standard cells. The first set makes lead froth, the second makes a little lead but mostly zinc and the third makes zinky middlings which are returned to earlier cells. Both the lead froths and the zinc froths are run over Wilfley tables to separate still further the lead, iron, and zinc and the final concentrates are thickened in Dorr thickeners and filtered in Portland filters.

For the lead flotation the reagents used are coal tar, cresylic acid, soda ash, sodium silicate, and occasionally gasoline and bleaching powder; to the zinc cells they add coal tar, cresylic acid, hard wood creosote, pine oil, sulphuric acid and niter cake. This makes it a true differential flotation controlled by the conditions. The aim is to throw the gold, silver and copper into the lead product with some sacrifice in grade of lead, and to make a high-grade zinc product as free as possible from gangue and the four other metals. Thus the operation is always carried on as a compromise and is governed by economic considerations and metal prices rather than by aim for highest extraction. It is found that the

[1] C. A. Wright, J. G. Parmelee, and J. T. Norton, *U. S. Bur. Mines Bull.*, **205** (1920).
[2] *Eng. Min. Jour.*, **110**, 20 (1920).

lead floats first, followed by the copper and silver. The gold and iron come up fairly uniformly, but the zinc floats last. The rates of flotation of the different minerals appear to be affected more by the amount and character of the grinding than by the reagents. Finer grinding tends to increase the rate of flotation of the gold but to destroy the preferential lead work, which may be partially offset by using less reagents. The final result is that although it would be possible to separate the lead and zinc into fairly good products, the lead product actually assays considerably under 45 per cent. lead on account of the economic necessity of keeping the gold, silver, and copper out of the zinc product as far as possible.[1]

A comprehensive account of the different preferential flotation processes at Broken Hill has been given by C. C. Freeman,[2] including a discussion of conditions, adjustments and apparatus. A new process which gives as good results as the Bradford sulphur-dioxide process has displaced the Bradford process at the Junction North mine. A solution is made of sulphur by boiling tar or other oils in a weak solution of sulphuric acid in the presence of an excess of powdered sulphur. This prevents the flotation of zinc with the lead, and the later blende flotation is obtained by only heating the pulp to about 120°F.

The story of the Bradford sulphur-dioxide process at Midvale, Utah, has been told by W. D. Green and W. Fagergren.[3] A lot of trouble was experienced at first when it was thought necessary to remove pine oil from the mixed sulphide flotation concentrates by caustic soda and to use sulphur dioxide, sulphuric acid and hyposulphite along the line of Australian practice. It was later found that the process could be much simplified, and the present practice is to take the gravity mill tailings, thicken them to 25 per cent. solid and treat them in Janney emulsifiers and Janney mechanical-air machines which have been fitted with air pans. The tailings from these go to waste and the concentrates are cleaned twice in pneumatic cells which make tailings back to the Janney machines and concentrates to the lead plant. In the lead plant the pulp passes continuously through four lead pulp tanks in series and is delivered with a content of 20 per cent. solid to the lead flotation machines. Sulphur-dioxide gas is introduced into the first two of the four lead tanks, proper gassing being regulated by returning varying proportions of the feed to the lead cells back to the first tank. The lead cells consist of four 6-ft. Fagergren flotation machines in series, the essential feature of which is that the pulp is always in motion and the froth is still except for its movement up over the lip. Oil is added to each of these machines as

[1] *Eng. Min. Jour.*, **109**, 838 (1920).
[2] *Austr. Inst. Min. Met. Proc.*, **36**, 89 (1920). *Min. Sci. Press*, **120**, 833 (1920). *Eng. Min. Jour.*, **109**, 1179 (1920).
[3] *Min. Sci. Press*, **121**, 455 (1920).

required. The lead concentrate produced contains an excessive amount of fine silica which hinders filtering. The concentrate is first thickened in a 30-ft. Dorr thickener and then filtered in a 6 by 6-ft. Oliver filter, live steam being introduced into the pulp within the filter to hasten filtering.

The tailing from the lead cells goes to a 30-ft. Dorr thickener and thence to two 8 by 10-ft. tanks where it must remain a sufficient time to eliminate the sulphur-dioxide gas by the addition of sulphuric acid and heating to 130°F. The pulp from these goes to two 6-ft. Fagergren flotation machines, where a very small amount of oil is added to float the zinc. The first machine makes a finished zinc concentrate and the second machine makes a middling product which goes back to the pneumatic cleaning cells of the first plant, and tailings to waste. Daily assays over a period of a month show the following ranges.

	Zinc, Per Cent.	Lead, Per Cent.
Janney feed	4.2– 7.8	1.9– 4.1
Janney tailing	1.1– 2.8	0.2– 1.0
Pneumatic-cleaner concentrate	26.1–35.0	12.5–21.4
Lead-cells concentrate	9.9–17.7	36.6–49.2
Lead-cell tailing	24.2–38.5	3.8– 9.0
Zinc-cells concentrate	36.9–42.5	4.7– 9.3
Zinc-cells tailing	2.1– 4.4	4.7– 6.9

Eighty per cent. of the lead in the zinc tailing is oxidized, only 20 per cent. being lead sulphide.

The low grade of the zinc concentrate is due to the tendency of iron to stay with the zinc. It has been found that by taking the heated pulp from the de-gassing tanks before adding acid, and re-running it, an iron-lead product can be floated which leaves a tailing from which a 50-per cent. zinc concentrate can be made. It is planned to incorporate this operation in the flow-sheet.

The applicability of the Bradford process has been discussed and comparisons made with other concentration, leaching and fire processes for complex ores.[1] It has been found applicable to a large percentage of lead-zinc-iron ores, lead-zinc ores and iron-zinc ores, particularly ores containing gold and silver, and also to a considerable number of copper-zinc ores. It has the advantage of simplicity and uses common reagents. The flotation cell used should be such as to allow independent control of the agitation and aeration, as for example the Hebbard Subaeration cell and the Little Janney cell. The electrolytic process requires a large plant and large expenditure. The Horwood roasting process is more costly and delicate, but probably gives better results on copper-zinc ores. Magnetic separation does not work on slimes and requires preliminary roasting. The Terry ammonia process has the advantage of simplicity. Any differential process which deadens the floating of lead

[1] *Eng. Min. Jour.*, **109**, 700 (1920). A. H. Heller, *Eng. Min. Jour.*, **109**, 1104)1920).

or iron and floats the zinc sulphide first has the disadvantage of floating the bulk of the gold, silver and copper with the zinc. J. B. Parker[1] reports considerable success in experimenting on lead-zinc ores with the Bradford process.

To overcome the delicate control required of the roasting in the Horwood process, H. L. Hazen[2] proposes a modification for copper-zinc ores whereby the mixed sulphide concentrates are roasted at a temperature in excess of 300°C. a sufficiently long time to completely oxidize the copper sulphides. The copper sulphate is leached out with water sufficiently acidulated with sulphuric acid to remove any zinc oxide that may have formed. The copper may be recovered from solution by precipitation on scrap iron, but the little zinc that goes into solution is lost. The leached residue is floated to make a high-grade zinc concentrate and a tailing which is mainly copper with a little zinc.

The preferential separation of molybdenite from pyrite and gangue at Empire, Colo., was referred to in MINERAL INDUSTRY, **28,** 773 (1919). The complete story of the experience with too fine grinding and improper oils which led to the final successful flow-sheet employing coarser grinding, pine oil alone, and simple two-stage flotation with the elimination of the cleaning tables has been told by W. H. Coghill and J. P. Bonardi.[3] Similarly the separation of molybdenite from pyrite and gangue at Quyon, Quebec, has been described by C. E. Oliver.[4] Here the process includes Callow cells and a Callow screen. The froth from the cells contains both molybdenite and pyrite, but the former comes up in flakes as coarse as ⅛-in. in diameter at times and is thus separated from the pyrite by passing over the 80-mesh Callow screen which makes molybdenite oversize and pyrite undersize.

Machines.—The Ruth machine continues to find favor on account of its simplicity, efficiency and low power-consumption. The remodeled Phelps Dodge plants are reported to be using long flat Callow cells, 18 or 20 ft. long and 18 in. deep, the K. and K. machines having been discarded as being too expensive in repairs. The Minerals Separation cells are very little used in the Southwest.

The Minerals Separation have developed a new Subaeration type of machine, called the Wilkinson and Littlefield, which has the advantage of absolutely positive flow of pulp. It consists of a series of cells 42 in. square with impellers at the bottom and vertical baffles above. Pulp flows from a point about half way down a cell, through a duct delivering to the under side of the impeller of the following cell. Froth flows over directly from the sides of the cells without the use of spitzkasten.

[1] *Eng. Min. Jour.*, **109,** 848 (1920).
[2] *Min. Sci. Press*, **120,** 455 (1920).
[3] *Eng. Min. Jour.*, **109,** 1210 (1920).
[4] *Eng. Min. Jour.*, **109,** 840 (1920).

Some tests of flotation machines at Nacozari, when the machines were all making about the same grade of concentrates and tailings, showed 350 tons treated by Minerals Separation using 185 hp., 450 tons by Callow with 100 hp., 40 tons by K. and K. with 12 hp., and 55 tons by the Ruth with 10 hp.

The Simpson flotation cell[1] has a pneumatic air-lift in the agitating compartment and has the spitzkasten divided into two sections by a vertical baffle-board which does not extend quite down to the sloping bottom. The section next to the agitating compartment has a porous air mat in it to give pneumatic flotation.

The Allingham machine is a Callow cell with swaying air mats, the bottom of the machine being horizontal and not inclined as in the Callow. The mats make 25 to 45 oscillations per minute and the bottom of the tank is curved to correspond to the arc of movement, and the tank narrows toward the top to reduce the frothing area.[2]

The Fahrenwald machine[3] resembles the Ruth and Groch types in having a hollow shaft which delivers air from above and pulp from below to the impeller. Low power-consumption with quiet separation in the spitzkasten is claimed for this machine.

The Colburn machine[4] has a high-speed revolving horizontal agitator separate from the spitzkasten which emulsifies the pulp and creates circulation by means of a vacuum.

The concrete porous bottoms in the Callow cells of the Ray Consolidated Co. are reported to be still rendering satisfactory service.[5]

Some experimental work has shown that the air bubbles in pneumatic cells are so finely divided as to have no initial velocity and rise solely on account of their buoyancy. The effect of increased air pressure is merely to increase the volume of air rising without any increase in velocity.[6]

The Hercules cell used at the Arizona Hercules mill is of the pneumatic Callow type, each cell being about 33 ft. long, 4 ft. wide and 3 ft. and 5 ft. deep at feed- and discharge-ends respectively. Four such cells, side by side, are built in one unit.

The Jones-Belmont flotation cells used in the Belmont Shawmut mill on the California Mother Lode, are built in a single unit of reinforced concrete. This mechanically agitates the pulp by impellers making 350 r.p.m. and also introduces air at the bottom, at a pressure of 3 lb. per sq. in., through special woven blankets which are riveted to the top of a ¼-in. screen.[7]

[1] S. F. Eaton, *Eng. Min. Jour.*, **110**, 553 (1920). *Ariz. Min. Jour.*, **4**, 22, Aug., 1920.
[2] E. I. Mills, *Eng. Min. Jour.*, **110**, 243 (1920).
[3] F. A. Thomson, *Min. Sci. Press*, **120**, 871 (1920).
[4] *Eng. Min. Jour.*, **110**, 933 (1920).
[5] H. C. McCrae, *Eng. Min. Jour.*, **109**, 837 (1920).
[6] M. S. Donaldson, *Min. Sci. Press*, **120**, 940 (1920).
[7] A. B. Parsons, *Min. Sci. Press*, **121**, 659 (1920).

The Peterson pneumatic cell used at Anyox, B. C., is a combined flotation machine and classifier in that the air mat is a pipe-grating with spaces between the pipes to allow coarse particles to drop through into the hopper-bottom of the cell, which is fitted with a spigot. Feed comes in through a central vertical inlet delivering just below the air mat and the pulp then rises through the spaces in the air mat and becomes subjected to the action of the air to form froth which rises and overflows one side while tailings pass under a baffle and discharge at the other side. The bottom spigot-discharge is limited to a small amount of coarse sand which is able to settle and which would accumulate on the mat in an ordinary pneumatic cell. The particular advantage of this machine is its suitability to a feed carrying some coarse particles.

For cleaning copper concentrates from the primary flotation cells at Mount Lyell a Waterhouse high-pressure water-jet flotation cell is used, which consists of a deep launder-shaped box with bottom sloping about 20°. A baffle-plate is installed above the bottom and parallel to it. Vertical pipes from above having outlets underneath the baffle-plate bring down atomized air by means of $\frac{3}{16}$-in. ejectors operated by water under 80-lb. pressure.

Oils and Reagents.—Considerable investigation and advance have been made on organic frothing agents, but information as to results is largely withheld. Oily reagents are not essential and other reagents are used, even colloids and colloidal solutions. The Minerals Separation Co. has also been developing the use of these organic reagents, especially for work on oxide ores and for preferential flotation. Among them are certain alcohols and soap.

The Inspiration Co. has successfully substituted pine tar for the high-priced steam-distilled pine oils. The purpose of the pine oil appears to be to make a froth and the pine tar answers the same purpose. Some laboratory experimental work has shown that this company has its tailings ponds contaminated by sewage, copper sulphate, and various drains from different portions of the plant, and this contaminated water when used over may be detrimental to flotation.

The Scott patents for the use of volatilized oil in flotation have been taken over by the Minerals Separation Co., although the Ray Consolidated and allied companies retain the right to their use. This has been successful at Ray where the oil is atomized mechanically into compressed air heated to about 200°F. Where the oil is vaporized by direct boiling the vapor is not uniform owing to the tendency of the more volatile fractions to come off first.[1]

Where oils give results in mills which are not up to the results obtained

[1] *Eng. Min. Jour.*, **109**, 1007 (1920).

in laboratory testing, F. G. Moses[1] points out that the mill conditions may not be the same as laboratory conditions in that differences may occur in the method of grinding, in the temperature of the pulp, in the manipulation of the pulp and reagents, in the character of the water used, and in the time of treatment; and he advises that mills should make thorough tests of various oil combinations in order to determine the most economical and efficient oil mixture.

Some further work on ores of the Consolidated Coppermines Co. involving the use of oil and Minerals Separation machines has been published by R. Linton.[2] These indicate that the X-cake and Xylidin results of mill work reported in MINERAL INDUSTRY, **27**, 814 (1918), are the best to date.

X-cake in water solution with lime would not float metallic copper in the Arizona-Hercules mill,[3] so a reconstructed oil was developed, consisting of light coal-tar creosote, pine products, and sulphur, redistilled in a reflux still, and this gave a satisfactory recovery of the copper sulphides, oxides and metallics.

For a California Mother Lode gold ore, the Belmont Shawmut mill uses 1¾ lb. per ton of a mixture of 3 parts of No. 2 Cleveland Cliffs wood creosote and 4 parts of California fuel oil, added in tube mill, and also ¼ lb. per ton of 60-per cent. sodium sulphide. The cheap oils give just as good results as pine and other more expensive oils, and the sodium sulphide is vital for success, the tailings assaying 0.01 oz. gold per ton with its use and 0.045 oz. without. It seems to have a scouring effect on the sulphides, causes them to flocculate and deflocculates the gangue. For economy it is added in the cleaner cells instead of in the tube mill.

Sodium sulphide is also used on an oxidized lead ore at the Shattuck-Arizona mill,[4] at the rate of 3 lb. per ton of ore, in connection with a mixture of coal-tar creosote and hard-wood creosote in the primary cells and a mixture of oil tar, coal creosote, wood creosote and sometimes a little pine or eucalyptus in the secondary cells. The work of the machines is very sensitive to the amount of sodium sulphide, so that its addition is very carefully controlled.

In connection with the U. S. Bureau of Mines tests on Idaho lead-zinc ores it was found that soda ash, sodium hydroxide, sodium silicate, salt, lime, coal-tar creosote, alcohol, gasoline and charcoal seemed to assist in the selective separation and recovery of lead sulphide in the presence of zinc and iron sulphides; also that for floating zinc after the lead had been removed copper sulphate or some other copper compound added to a

[1] *Min. Sci. Press*, **121**, 238 (1920).
[2] *Am. Inst. Min. Met. Eng.*, June, 1920; Feb., 1921.
[3] J. T. Shimmin, *Eng. Min. Jour.*, **109**, 1115 (1920).
[4] G. L. Allen, *Eng. Min. Jour.*, **110**, 759 (1920).

pulp containing soda ash gave good results. The best mixture varied with different ores.

Crude trona, a combination of neutral and acid sodium carbonate, is added to the crude chalcopyrite ore in the Swansea Lease mill at the rate of 10 to 15 lb. per ton of ore. This mill uses ⅛ lb. per ton of P. E. No. 1 oil in the tube mills and ¼ lb. in the flotation cells, a 50-50 mixture of No. 5 G. N. S. steam-distilled pine oil and No. 8 pine-tar oil being added in the primary cells, and a 70-30 mixture of No. 4 Barrett coal-tar creosote and No. 28 coal-tar oil being added in later cells.

The detrimental effect of colloidal lime in floating a silver ore at Guanajuato, Mexico, is reported by B. R. Bates.[1] The remedy is either to wash out the colloid to waste or to use less lime in the mill water and precipitate whatever is present by adding soda ash prior to flotation.

Final report has been submitted by M. H. Thornberry and H. T. Mann[2] on the effect of chlorides, acetates, oxalates, chromates, carbonates, permanganates and other salts in the flotation of a Missouri lead ore. Considering both the extraction and the grade of concentrates the effect was occasionally beneficial, but in most cases these addition agents either were of no benefit or were definitely harmful to a greater or less degree depending somewhat on the kind of oil used.

Handling Concentrates.—The practice still continues little changed, with Dorr thickeners and Oliver or American filters as the commonly used apparatus, but the preparation of flotation concentrates for shipment is capable of further improvement, especially from the viewpoint of the smelter man who finds the wet sticky material difficult to unload, handle, dry and roast uniformly. A new type of dryer, devised by Elmer Brain at Kellogg, Ida., is reported to be giving good results.[3]

Testing.—Apparatus and methods for laboratory testing of ores by flotation have been described in detail by J. M. Hyde,[4] including a simple bottle test, mechanical agitation test and pneumatic agitation test. For general testing he advises a mixture of three parts Pensacola Tar & Turpentine Co.'s No. 400 pine creosote or its equivalent, three parts of carbolic creosote, and one part of crude coal tar or pitch. For thickening the products he suggests a folded paper towel which, bent over the edge of the pan, takes the water away by capillary action.

Theory.—I. Langmuir[5] has discussed flotation as a surface phenomenon involving molecular adsorption hypothesis, while P. Vageler[6] has considered it from the viewpoint of colloidal chemistry.

[1] *Eng. Min. Jour.*, **109**, 552 (1920).
[2] *Mo. Sch. Mines Bull.*, **5**, No. 2 (1919).
[3] *Min. Sci. Press*, **120**, 460 (1920.)
[4] *Min. Sci. Press*, **121**, 481 (1920).
[5] *Trans. Faraday Soc.*, **15**, 62 (June, 1920). *Min. Sci. Press*, **121**, 913 (1920).
[6] *Metall u. Erz*, **17**, 113 (1920). *Zeit. Ver. Deut. Ing.*, **64**, 19 (1920).

H. R. Adam[1] has made a thorough and critical resumé of all the various scientific theories and laws that have been advanced to explain flotation phenomena.

Litigation.—This has progressed during 1920 through the handing down of several interlocutory decrees, although there have been no main case decisions during the year.

One additional suit has been brought, that against the Magma Co., Jan. 10, 1920, by both the Minerals Separation, Ltd., and Minerals Separation North American Corporation, for infringement of patents No. 835,120, their principal process patent, and No. 962,678, the soluble frothing agent patent. Neither this nor the Nevada Consolidated suit which was brought Sept. 9, 1919, has as yet reached a hearing.

The interlocutory decrees, above referred to, have principally been in the Miami case and would seem to have the possibility of wide general importance in the flotation litigation, in that they may not only have an important bearing on the scope to be given the claims of the Minerals Separation patents, but, in one instance, may develop to have such a bearing on the validity of the disclaimer made by Minerals Separation respecting the three claims of patent No. 835,120, which were disallowed by the Supreme Court in the Hyde case decision, as to present even a possibility of disbarring all of the suits under this patent.

As affecting the scope which should be given the claims of the patents, there was disclosed in the reply of the Miami Co. to a petition which was filed May 4, 1920, for leave to file a Supplementary Bill finding the Miami Co. in contempt of court, a remarkable unpublished manuscript written by Sulman and Picard, two of the co-inventors of the process, shortly after the date of the invention, which manuscript frankly states a knowledge of the state of the art which these inventors at that time had, which is quite inconsistent with the very broad claim which Minerals Separation is now seeking to establish before the United States Courts.

Judge Morris of the U. S. District Court refused to grant any of the petitions of the Minerals Separation Co., so that they took an appeal to the U. S. Circuit Court of Appeals in Philadelphia and on Dec. 9, 1920, this court rendered its decision sustaining Judge Morris in his dismissal of the various petitions of the Minerals Separation Co. This opinion of the U. S. Circuit Court of Appeals, the court which made the law in the Miami case, is of much importance because of the light which it throws upon the attitude of this court on the question as to whether operations of the Miami Co. since October, 1915, are or are not merely colorable departures from the process as described in the patents. After reading all the testimony and carefully considering all the facts and applying the

[1] *Jour. Chem. Met. Min. Soc. So. Afr.*, **21**, 17, 62 (1920). *Min. Sci. Press*, **121**, 765](1920).

law, which this Court had itself made, it failed to find any grounds for contempt proceedings, which is significant.

Upon the same day upon which the Minerals Separation made its motion for the Supplemental Bill seeking to have the Miami Co. punished for contempt of court, it also made a motion for leave to file a Supplemental Bill with the purpose of making Minerals Separation North American Corporation a party to the Miami suit. The facts which were developed in this motion were such as would make it appear that this American Corporation had been an owner of patent No. 835,120 at the time that the disclaimer as to the three invalid claims was made, and yet that this ownership had not participated in the making of the disclaimer, as by law it should have done, a fact which would, according to the law, invalidate the entire patent No. 835,120. As opposing such a contention the Minerals Separation Co. makes the somewhat technical distinction that the North American Corporation was not actually an owner of the patent, but merely entitled to all earnings and emoluments to be derived from the patent. This is still before the District Court, the arguments not yet having been made.

In February, 1920, Judge Bourquin of the U. S. District Court of Montana dismissed contempt proceedings which Minerals Separation, Ltd., had brought against the Butte and Superior Co., their cause for action being their claim that the Butte and Superior was not using more than 1 per cent. of oil in its flotation operations. The question here involved as to the oil returned to the cells with the middlings was a phase which Judge Bourquin concluded had not been decided by the Supreme Court. The question, having been only partly litigated, he could not find contempt and dismissed the proceeding.

The Butte and Superior case is still in the accounting stage. Early in the year the Minerals Separation filed a bill of exceptions against the Butte and Superior's account of damages to be paid to the Minerals Separation Co. not exceeding $471,000. Later on in the year the Butte and Superior filed a statement covering their operations during the period of infringement.

Hearings in the Miami case before the Master have proceeded throughout the year. The amount of damages which may be assessed is dependent upon the standards of comparison which may be established and, in the Miami case, also as to whether the operations since October, 1915, are found to be more than a mere colorable departure from the process as described and distinctly set forth in the patents. Concerning this every one interested should carefully read the opinion of the Circuit Court of Appeals of Philadelphia of Dec. 9, previously referred to.

The American Mining Congress at its Denver session devoted con-

siderable time to a discussion of the Minerals Separation controversy and to the justice of their patent and royalty claims. There exists an opportunity for the company and the flotation operators to adjust their differences through the medium of an impartial committee of this association.[1] The addresses by G. H. Montague and G. L. Nye on the objectionable practices of the Minerals Separation with a summing up of the present position of the company under the patent laws and anti-trust laws, including the various court decisions, have been published in full.[2] These two gentlemen are of the counsel for the Federal Trade Commission against the Minerals Separation Co.

The hearings of the Federal Trade Commission to obtain evidence regarding the connections, operations, and practices of the Minerals Separation Co. have continued and various information has been brought out, but no final action has been taken as yet.[3]

Operation and Details of Practice.—A discussion of flotation at the Idaho School of Mines by various operators[4] brought out a lot of good ideas on testing ores for flotation and on the operation of flotation plants, with suggestions as to further investigations and improvements.

Details of developments in the 400-ton experimental mill of the Arizona Copper Co., given by A. Crowfoot and E. Wittenau,[5] show a record of continuous improvement. Starting with a flow-sheet like the Inspiration with 48-mesh grinding and pneumatic flotation followed by classification and tabling of sands, the following changes were made successively and with definite improvement at each change: (1) Substitution of X-cake and Xylidin for oils; (2) rearrangement of roughing and cleaning flotation; (3) elimination of tables, with regrinding of sands to 65 mesh; (4) installation of tables at 6 mesh to save pyrite for its sulphur and iron content, the remainder being ground to 65 mesh and floated; (5) doubling the flotation area by installing shallow Callow cells 16 ft. long, 25½ in. wide, and 15 in. deep at feed-end and 17 in. at discharge-end.

The mill of the Swansea Lease in Arizona, described by L. F. Barber and F. L. Thurmond,[6] is a small simple mill using Blake breaker, ball mill with Dorr classifier, and roughing and cleaning flotation machines of the Minerals Separation type. The ore is chalcopyrite with hematite, a little pyrite and a silicious gangue. With an ore assaying 1.5 to 3 per cent. copper an extraction of 97 to 99 per cent. is made in a concentrate

[1] *Am. Min. Congress Jour.*, **6**, 645 (1920). *Eng. Min. Jour.*, **110**, 1038, 1070 (1920). *Min. Sci. Press*, **121**, 790 (1920).
[2] *Min. Sci. Press*, **121**, 833, 873 (1920).
[3] *Am. Min. Congress Jour.*, **6**, 316 (1920). *Chem. Met. Eng.*, **23**, 124 (1920). *Min. Sci. Press*, **120**, 698, 710, 909 (1920); **121**, 263 (1920). *Eng. Min. Jour.*, **109**, 1037, 1229 (1920); **110**, 132, 182, 228, 815 (1920).
[4] *Min. Sci. Press*, **120**, 459 (1920).
[5] *Eng. Min. Jour.*, **109**, 1349 (1920).
[6] *Eng. Min. Jour.*, **109**, 845 (1920). *Min. Sci. Press*, **120**, 606 (1920).

assaying 0.45 oz. silver per ton, 23.12 per cent. copper, 10.4 insoluble, 31.4 iron, 28 sulphur, and 1 per cent. lime.

The flotation mill for Mount Lyell copper ore[1] uses grizzly, Blake breaker and rolls and an ⅛-in. shaking screen partly submerged in water, followed by cone classifier and tube mills to grind to 10 per cent. on 60 mesh. Pulp is thickened in Dorr thickener and treated in standard Minerals Separation machine which makes tails to a single tails-cleaning cell of the cascade type and concentrates to a cleaning cell of the Waterhouse water-jet pneumatic type.

A general article by R. D. Nevett,[2] from the viewpoint of Broken Hill practice, deals with the various factors controlling flotation, including crushing, rate and regularity of feed, density of pulp, temperature, oils and addition agents, condition of circuit water, agitation, and aeration.

Accessory Apparatus

There is a tendency to get away from bucket elevators, especially in coarse-crushing plants, and substitute inclined belt-conveyors, which are a little more expensive and require more ground space but effect a large economy of operation and save a lot of trouble. This practice has been followed for a long time by Witherbee Sherman at Port Henry and is a feature of the new crushing plants of the Utah Copper, the Canada Copper and the Alvarado companies.

At the Alaska Gastineau mill an automatically operated hoisting skip was installed instead of an elevator for coarse ore.

J. S. Watts has made a detailed study of the forces in the Marcus shaking conveyor[3] and has also furnished some good practical points on design of chutes and ore-bins.[4]

At the Bunker Hill mills the launders are painted brown for concentrates, yellow for middlings and gray for tailings. The main tailings launder is lined with concrete slabs 2 in. thick, 24 in. long, and 12 in. wide, made of tailings and cement. They cost 20 cts. each as against $3.50 for cast iron. White-iron cross riffles, ¾ in. thick, 6 in. high and 24 in. long (the width of the launder) are placed at intervals of 24 in. The tailings settling between the riffles prevent wear of the concrete bottom.[5]

To save labor, wear of machines and metal losses and to keep the atmosphere free from dust the Arizona Copper Co. has installed a dust-collecting system consisting of hoods over crushing and conveying

[1] L. V. Waterhouse, *Austr. Inst. Min. Met. Proc.*, **38**, 105 (1920). *Mining Mag.*, **23**, 315 (1920).
[2] *Austr. Inst. Min. Met. Proc.*, **37**, 55 (1920). *Mining Mag.*, **23**, 246 (1920). *Min. Sci. Press*, **121**, 349 (1920).
[3] *Can. Min. Jour.*, **41**, 1015 (1920).
[4] *Can. Min. Jour.*, **41**, 817 (1920).
[5] T. A. Rickard, *Min. Sci. Press*, **120**, 529 (1920).

machinery and ducts leading to a Cyclone dust-collector connected to an exhaust fan. In crushing 237 tons of copper ore per hour 174 lb. of dry dust assaying 2.34 per cent. copper was collected per hour.[1]

The life of the lining of a Campbell and Kelley centrifugal sand pump at the Belmont Shawmut plant has been considerably lengthened by filling in behind the liners with concrete made of cement and sand. When the liners wear through in one or two spots it is unnecessary to replace them until the concrete also wears sufficiently to expose the pump casing.[2]

Principles, Theory and General Ideas

Several articles have appeared dealing with testing and general operation.

The discussion of the economic side of concentration by R. S. Handy and A. P. Watt[3] has called forth some critical remarks by R. T. Hancock,[4] who presents his views on economic extraction and the most economic grade of concentration as affected by costs and smelting charges and as affecting the further treatment of middlings and possibly also tailings.

The checking of the operations of concentrating machines and of the entire mill, by weighing, sampling, analyzing and using formulas, in order to keep track of the work which each machine is doing, has been covered by D. Lay,[5] while good ideas on the selection, installation and operation of the electrical equipment in the mill have been supplied by B. B. Becket.[6]

Critical analysis of tin dressing, referring especially to Cornish practice and the results of the extensive research of the Tin Research Committee on Cornish ores, has been made by E. Edser,[7] who makes extensive mathematical comparisons of the various tests to find a relation between the amount of cassiterite lost and the enrichment effected; and by R. T. Hancock,[8] who calculates the efficiency of each step in Cornish tin dressing in order to demonstrate the low efficiency of many of the steps.

J. J. Collins[9] has viewed the Cornish tin dressing from a little different angle, taking up the losses resulting from existing methods of crushing, classifying and tabling, and suggests a chemical process to ensure a greater recovery of tin.

A study of the concentration processes for low-grade porphyry copper

[1] M. R. Hull, *Chem. Met. Eng.*, **22**, 207 (1920).
[2] A. B. Parsons, *Min. Sci. Press*, **121**, 659 (1920).
[3] Mineral Industry, **28**, 785 (1919).
[4] *Eng. Min. Jour.*, **109**, 841 (1920).
[5] *Eng. Min. Jour.*, **109**, 847 (1920).
[6] *Eng. Min. Jour.*, **109**, 849 (1920).
[7] *Inst. Min. Met.*, **28**, 89 (1919).
[8] *Mining Mag.*, **23**, 346 (1920).
[9] *Mining Mag.*, **23**, 285 (1920).

ores shows that the systems involve table concentration combined with flotation as follows:[1]

1. Primary concentration followed by flotation.
2. Primary concentration followed by flotation and secondary concentration.
3. Primary flotation followed by concentration.
4. Primary flotation followed by concentration and secondary flotation.
5. Flotation alone.

Primary flotation or flotation alone has the advantages of simplicity and less expense for plant. Where primary concentration is practiced, thickening plants must be installed to dewater the table tailings prior to flotation. For best results on tables, good classification to separate the sand clean from the slimes is essential.

Examples of Practice

Perhaps the most astonishing change in milling practice is the elimination of Hancock jigs in the Bonne Terre mill in Southeast Missouri. The ore of this district averages about 4 per cent. lead in the form of clean galena in dolomitic limestone gangue.[2] The general practice in the district is to crush to 9 mm., size at 2 mm., and send 9 to 2-mm. material to Hancock jigs, 2-mm. to 150-mesh material to tables, and slimes to flotation. The jigs and tables make clean concentrates and tailings, and middlings which are re-crushed in rolls and go back into the original ore stream.

The Bonne Terre people made a careful study of the ore and tried many flow-sheets involving various arrangements of crushing and concentration. It was found that the amount of free galena in 3-mesh material was very small; in 14-mesh size, 50 per cent.; and in 35-mesh size 80 per cent. Only 15.4 per cent. of the lead in 9 to 2-mm. jig feed was free galena, but 87.2 per cent. was free in the table feed, 2 mm. to 150 mesh.

Four flow-sheets will serve to illustrate the line of investigation.

Flow-sheet 1 is the general practice as outlined above.

Flow-sheet 2 is the same except that Hardinge ball mill is substituted for the regrinding rolls and does better work in regrinding the finer middlings.

Flow-sheet 3 regrinds the jig and table middlings in rolls as before, but regrinds all jig tailings in the Hardinge mill and sends the ground product back into the original ore stream.

[1] *Min. Sci. Press*, **121**, 419 (1920).
[2] L. Delano and H. Rabling, *Am. Inst. Min. Met. Eng.*, July,1920. *Eng. Min. Jour.*, **110**, 567 (1920).

Flow-sheet 4 grinds all the oversize of 2-mm. screen and sends it to the tables and flotation.

A summary of the economic data is given in the table, the weights being per ton milled, and the costs being the difference per ton.

DIFFERENTIAL COSTS PER TON MILLED

	Flow-sheet 1.		Flow-sheet 2.		Flow-sheet 3.		Flow-sheet 4.	
	Pounds Weight.	Pounds of Lead.	Pounds Weight.	Pounds of Lead.	Pounds Weight.	Pounds of Lead.	Pounds Weight.	Pounds of Lead.
Jig concentrates.....	14.86	10.40	6.41	4.49	14.87	10.41	0.00	0.00
Table concentrates.....	57.00	39.90	64.10	44.87	61.10	42.77	71.80	50.26
Flotation concentrates.	27.75	16.65	35.20	21.12	32.30	19.38	37.80	22.68
Total concentrates.....	99.61	66.95	105.71	70.48	108.27	72.56	109.60	72.94
Extraction, per cent....	83.69		88.08		90.70		91.18	
Milling cost.....	$0.0067		$0.0144		$0.0409		$0.0000	
Freight, smelting and royalty cost.....	0.0000		0.0435		0.0485		0.0655	
Total.....	0.0067		0.0579		0.0894		0.0655	

Flow-sheet 3 shows the maximum milling cost, the difference being $0.0409 per ton from the minimum cost obtained by flow-sheet 4. Flow-sheet 4 shows the highest cost for freighting and smelting concentrates and paying royalty charges, being $0.0655 above the minimum of flow-sheet 1. Total extra costs are a maximum for flow-sheet 3, being $0.0827 above the minimum of $0.0067 in flow-sheet 1. Although the extra cost of flow-sheet 4 is $0.0588 (0.0655 minus 0.0067) over flow-sheet 1, this is much more than offset by the value of the lead in the 7.49 per cent. extra recovery (91.18 minus 83.69).

One-half of the mill has operated for six months with the jigs removed and the results are highly satisfactory. The original paper contains a lot of further valuable information on the details of the investigation.

Wisconsin zinc-milling methods have also been studied and the result is a radical change. Instead of using a rougher jig making only finished tailings and middling products to be re-crushed and cleaned on a cleaner jig, the first jig now makes clean concentrates, and tailings which are not finished but go to the second jig, which makes no finished concentrates but finished tails to waste, and middlings returned direct to the first jig. All re-crushing of middlings is eliminated. This revision means simpler flow-sheet, cheaper mill, 50 per cent. increase in capacity, 50 per cent. decrease in tailings losses, with no serious effect on the grade of concentrates.

The Alaska Juneau mill is gradually remedying the defects of the original flow-sheet and construction and each year shows increased capacity and extraction with reduced costs. The principal improvement

is in sorting out coarse waste, but even further changes have been made from the proposed revision of flow-sheet given in MINERAL INDUSTRY, **27,** 822 (1918). Shortage of labor and funds has delayed matters, but they are now close to a tonnage of 7000 tons of mine-ore per day with 40 per cent. eliminated by sorting and with a cost of 28 cts. per ton to cover the entire crushing, sorting and milling. Later, when more funds become available, they expect to attain 16,000 tons daily, with 50 per cent. elimination, 80 per cent. extraction and an entire milling cost of 20 cts. per ton. The report for 1920 shows 942,870 tons mined, of which 305,549 tons was rejected in the mill at a size over 2 in. The average assay was $1.09 in gold per ton and the recovery was $0.78, or 71.56 per cent. Costs were $0.21 per ton for mining, $0.446 for milling, and $0.09 for general expense.

A story of the testing plant of the Alaska Gastineau Co., together with details of construction and flow-sheet of the main mill and results of operation, has been written by E. A. Daveler.[1] It is unfortunate that this plant should have been shut down owing to the fact that the grade of ore did not come up to the estimate and in spite of the fact that the operating results of the mill actually bettered the original estimates of extraction and operating costs.

The various Phelps Dodge copper mills at Bisbee, Tyrone, and Nacozari are still under reconstruction. Details of the new features have not been given out, but primary and secondary fine rod-mill grinding to 48 mesh will be followed, with sand table concentration in between, and with pneumatic roughing and cleaning flotation following the secondary fine grinding and slime tables following the flotation.[2]

The original Arizona Hercules mill referred to in MINERAL INDUSTRY, **28,** 789 (1919) did not have sufficient capacity and did not save the metallic copper and oxides with the sulphides, so it has been remodeled to use jigs for coarse metallic copper and modified flotation to recover metallics and oxides.[3] The mill has three sections. One remodeled section with a capacity of 500 to 600 tons in 24 hr. is as follows, the ore having been previously crushed to 2½ in.:

(1) Ore-bins holding 2385 tons. By six pulley-type feeders, belt-conveyors, over Merrick automatic scale, to (2).

(2) One 8 by 6-ft. Marcy mill, to (3).

(3) One Dorr duplex classifier. Sands to (4); overflow, 5 per cent. on 28 mesh, to (7).

(4) Two jigs with one cell each. Concentrates to smelter; hutch by elevator to (5); tailings to (2).

[1] *Am. Inst. Min. Met. Eng.*, Jan., 1920. *Chem. Met. Eng.*, **22,** 361 1920).
[2] *Min. Sci. Press*, **121,** 284 (1920). *Eng. Min. Jour.*, **110,** 35 (1920)
[3] J. T. Shimmin, *Eng. Min. Jour.*, **109,** 1115 (1920).

(5) One Deister Overstrom table. Concentrates by elevator to (13); tailings to (6).

(6) One 6 ft. by 22-in. Hardinge ball mill in closed circuit with Dorr Simplex classifier. Classifier overflow through 65 mesh to (7).

(7) Bucket elevator to (8).

(8) Dorr duplex classifier. Sands by mechanical distributor to (9); slimes, 93 per cent. minus 80 mesh, to (10).

(9) Four Deister Overstrom tables. Concentrates by elevator to (14); tailings to (6).

(10) Four 4 by 32-ft. compartmented Hercules flotation machines. Froth from first five compartments to (11) and from last three compartments to (3); tailings to waste.

(11) Four 2 by 8-ft. Callow cells. Froth to (12); tailings to (3).

(12) Two 2 by 8-ft. Callow cells. Froth to (14); tailings to (3).

(13) Two 40-ton bins for coarse concentrates, for three sections.

(14) Two 16 by 24-ft. intermittent settling tanks. Thickened concentrates to stock tank and by elevator to (15); water to (16).

(15) One 8 by 12-ft. Oliver filter. Cake shipped to smelter; water to (16).

(16) One 10 by 40-ft. Dorr thickener, for three sections. Spigot to elevator in (14); overflow to (17).

(17) Two 10 by 20-ft. settling tanks. Settlings to elevator in (14); overflow to waste.

The jigs extract 30 per cent. of the copper in the ore as a concentrate assaying 42 per cent. copper and 17 per cent. insoluble. Figures over a 30-day period are as follows:

	Per Cent. Sulphide Copper.	Per Cent. Oxide Copper.	Per Cent. Metallic Copper.	Per Cent. Total Copper.
General mill feed	1.283	0.241	0.190	1.714
General concentrates	23.890	1.320	1.017	26.227
General tailings	0.077	0.076	0.101	0.254
Recovery, per cent	94.3	72.6	52.0	86.0

The new Iron Cap mill in Arizona started operations in June, 1920, and it is a model mill to treat 300 tons of copper ore per day with minimum use of elevators, conveyors and water. Briefly the flow-sheet is as follows:

(1) Ore crushed to 1 in. at the mine, comes to (2).

(2) Ore-bin of 650 tons capacity, followed by feeder, conveyors, elevator, Merrick weighing conveyors, to (3).

(3) Cole-Bergman 5 by 10-ft. rod mill, open circuit, grinding to 3 per cent. on 10 mesh. To (4).

(4) Four Deister Plat-O roughing tables. Concentrates to (10); tailings to (5).

(5) Dorr classifier in closed circuit with 5 by 10-ft. Cole-Bergman rod mill. Product, with 18 per cent. on 100 mesh, to (6).

(6) Two eight-cell Inspiration flotation machines, concrete construction. Froth to (7); tails to(8).

(7) Two four-cell Inspiration flotation machines, concrete construction. Froth to (11); tails to (6).

(8) Two 16-in. drag belt classifiers. Sand to (9); slime to (14).

(9) Six Deister Plat-O tables. Concentrates to (11); middlings to (6); tailings to (14).

(10) Four 12 by 8-ft. filter-bottom tanks for coarse concentrates. Concentrates to (13; water to (15).

(11) One 30 by 8-ft. Dorr thickener. Spigot to (12); overflow to (15).

(12) One 8 by 8-ft. Oliver filter. Cake to (13); water to (15).

(13) Conveyor-belts to shipping car.

(14) One 50 by 10-ft. Dorr thickener for tailings. Spigot to waste; overflow to (15).

(15) Two water-tanks for mill water.

The total water used is 316.08 gal. per min., of which 201.20 gal. is fresh water and 114.80 gal. is water recovered. While the mill operated in 1920 it treated 50,186 tons of copper sulphide ore assaying 5.04 per cent. copper and 1.487 oz. of silver per ton and yielded 8318 tons of concentrates assaying 24.50 per cent. copper and 8.09 oz. of silver per ton, thus showing a recovery of 93.7 per cent. of the copper and 90.2 per cent. of the silver at a milling cost of $2.17 per ton of ore treated.

The 400-ton Shattuck-Arizona mill treats lead carbonate ore with some cerargyrite in a gangue of quartz and iron oxide. Ore from the mine comes to (1).

(1) Bin holding 1000 tons. By 8 Jeffrey stationary steel apron-feeders, car, and conveyor-belts with magnetic head-pullley, to (2).

(2) Grizzly with 1.5-in. spaces. Oversize to (3); undersize to (4).

(3) No. 5 Telsmith gyratory breaker set at 1.5 in. To (4).

(4) Bucket elevator. To (5).

(5) Hummer screen with $\frac{5}{8}$-in. holes. Oversize to (6); undersize by conveyor-belt up 21½° incline and distributing conveyor, to (7).

(6) Traylor rolls, 42 by 16 in. To (4).

(7) Two ore-bins, 400 tons each. By six Challenge feeders, conveyor-belts, over automatic weighing scales, to (8).

(8) Whip-tap vibrating screen with 4-mm. holes. Oversize to (9); undersize with water to (10).

(9) Two 6 by 4½-ft. Marcy mills in closed circuit with 5-ft. Dorr duplex classifiers. Classifier overflow to (12).

(10) Two primary Butchart tables. Concentrates to (18); tailings to (11).

(11) One 12-in. drag classifier in closed circuit with a 4 by 10-ft. Allis-Chalmers ball-tube mill. Classifier overflow to (12).

(12) Two 6-ft. Allen sand cones. Sand to (13); slime to (16).

(13) Two secondary Butchart tables. Concentrates to (18); tailings to (14).

(14) Allen sand cone. Sand to (15); slime to (16).

(15) Two Butchart tables. Concentrates to (11); tailings to waste.

(16) Dorr thickener. Thickened pulp through agitator for oiling to (17); water to mill tank.

(17) Six K. and K. cells and two Rork cells arranged in four parallel units of two cells each. First froths to (19); second froths to agitator in (16); tailings to waste.

(18) Allen cone classifiers. Spigot is concentrates to filter bins for market; overflow to mill-water tank.

(19) Dorr thickener, 20 by 12 ft. Spigot to (20); overflow to mill-water tank.
(20) Oliver filter 8 by 6 ft. Cake to concentrates bin.

The mill has treated as high as 500 tons in 24 hr. It cost $275,000. Average results concentrating 5.56 tons into 1 are as follows:

	Oz. Gold Per Ton.	Oz. Silver Per Ton.	Lead, Per Cent.	Iron, Per Cent.	Insoluble, Per Cent.
Mill feed	0.059	7.22	6.27	13.73	65.99
Concentrates	0.227	28.53	32.92	20.6	22.3
Tailings	0.022	2.52	0.43	.....	.....
Recovery, per cent	69.4	71.3	94.4	.....	.....

A history of the development of the Bunker Hill milling system with detailed description of the various flow-sheets has been written by T. A. Rickard.[1]

Treatment of Coal

Practice.—Coal washing in the United States continues to gain, but is not yet receiving the scientific study that it deserves. The increase in washing may be ascribed (1) to the increased ability to market finer sizes of coal which formerly were thrown on the dump with considerable admixture of impurities, but which now can be sold at a profit if the impurities are washed out; (2) to the depletion of the high-grade low-sulphur coals and the resource to lower-grade higher-sulphur material which must have the sulphur and ash reduced by washing to make suitable coke; and (3) to higher prices and the market demand for a fuel with higher calorific power which make it profitable for the operator to wash his coal and obtain a higher price and at the same time save transportation costs. A session of the New York Section of the American Institute of Mining and Metallurgical Engineers[2] was devoted to a discussion of existing coal-washing conditions and recent developments in apparatus. H. C. Ray[3] has also considered the operation from the practical side, dealing with the actual conditions involved in the problem, and the various types of apparatus that find application, and including especially the apparatus for dewatering and drying the washed coal.

The scientific study of coal washing in England has made further progress and T. J. Drakeley[4] has reported results of his investigation of the efficiency of the operation, analyzing the views of other authors, and including results of extensive tests. He reaches the conclusion that absolutely fixed standards cannot be made for what shall be called coal and what shall be called dirt or refuse, owing to the variations in the character of the coal washed in different plants and the greater or less percentage of combined or irremovable ash in different coals; that for the

[1] *Min. Sci. Press*, **120**, 485, 525 (1920).
[2] R. D. Hall, *Coal Age*, **17**, 495 (1920).
[3] *Coal Age*, **17**, 2 (1920).
[4] *Inst. Min. Eng.*, **59**, 71 (1920). *Coll. Guard.*, **119**, 747, 815 (1920).

same reason the efficiency of the coal-washing operation should not be tested by determining the ash content of the products directly, but that the proper method is to make float-and-sink tests on the products, using heavy solution which may vary slightly for different plants, but in general is around 1.35 sp. gr. The ash content of the float-and-sink products may be obtained to provide further information on the efficiency of the process. In the case of most coals the fracture is such as to produce more slate or refuse in the coarse sizes.

The use of the microscope is very helpful in studying the character of a coal for decision as to the benefit which may be obtained by washing.[1]

A series of articles has appeared on Pennsylvania anthracite practice covering operations in the Old Forge and Price-Pancoast breakers at Scranton, the No. 11 Lehigh breaker near Coaldale, the Silver Creek breaker, the Alliance breaker at Kaska, and the No. 4 Kingston breaker at Edwardsville, and finally giving special attention to sprinkler systems for fire protection.[2]

The application of the flotation process to coal is the latest development of the Minerals Separation Co. and there are already operating plants in England, Belgium, Spain and China. Coal as coarse as $\frac{1}{10}$ in. can be floated in standard Minerals Separation machines using small amounts of common reagents. The separation is good and practically all the free ash is eliminated. Coal with 20 or 30 per cent. ash can be reduced to 10 per cent. ash commercially, or even to 4 per cent. by more careful treatment. By use of proper reagents the pyrite is kept from floating, and gypsum goes naturally with the waste, so that the sulphur content of a coal is reduced as well as the ash. The amount of reagent may not exceed $\frac{1}{2}$ lb. per ton, and cheap reagents such as the water from coke-oven gas-scrubbers may be used. The process is said to clarify the water at the same time. The Minerals Separation Co. has acquired options on a large tonnage of waste heaps in England. The special field for the process appears to be in treating these old heaps and fine sludge from washeries and even possibly recover coal from ashes, and produce a fine coal concentrate suitable for briquetting or for coking. Another outlet is the so-called colloidal fuel consisting of a mixture of fine coal and fuel oil. No report has been made as to whether flotation will work on anthracite, but in view of the fact that graphite can be floated it would seem as if anthracite should give no special difficulty. Whether it can find a field at the present time in competition with our plentiful supply of cheap high-grade coals has not yet been demonstrated. The flotation work in England on coal in the experimental plant of the Skinningrove Iron Co. by the Minerals Separation Co. has been described in detail by E. Bury.

[1] A. L. Booth, *Iron Steel Inst.*, **102**, 271 (1920). *Can. Min. Jour.*, **41**, 859 (1920)
[2] D. C. Ashmead, *Coal Age*, **17**, 483, 532, 841, 1039; **18**, 585, 671, 935, 995 (1920).

W. Broadbridge and A. Hutchinson.[1] It was found that the coal froth was sufficiently low in moisture to go direct to filters or continuous centrifugal driers, without using thickeners.

Apparatus.—Re-tipping the teeth of anthracite coal rolls is readily performed by the use of an oxy-actylene welding outfit on the rolls in place, at a cost of $64.28. This avoids the purchase of new rolls and provides a means of keeping the teeth well pointed for the production of minimum fines.[2]

Some information on the construction, operation, and power consumption of steel-plate picking belts has been written by J. S. Watts.[3]

For chute linings it has been found that galvanized sheet iron is better than blue-annealed sheet iron because coal will slide on it at a lower angle, it will not clog so readily, and it wears more evenly and has longer life. However, a cheaper and longer-lived lining than any kind of iron is vitrified clay, which may be readily obtained in half-cylinder form of ordinary sewer-pipe.[4] It would seem as if coal-washing operators might study the launder linings used in ore-dressing plants to advantage.

The new James jig, designed to treat small sizes of anthracite, even down to 1/16 in., has a fixed sieve, and below the sieve is what is in effect a plunger with valves in it. These valves close automatically on the up stroke of the plunger, thus creating pulsion through the jig bed, and open on the down stroke, thus avoiding suction.[5]

More attention is being paid to concentrating tables of the jerking type for coal. These give promise of handling feed as coarse as 1/2 in. in competition with jigs and delivering a high-grade product and requiring less attention than jigs. The Deister Concentrator Co. makes a special No. 7 Deister-Overstrom diagonal-deck coal-washing table which has a capacity of 6 to 8 tons per hour on anthracite coal and 7 to 10 tons per hour on bituminous coal.

Concentrating tables are now widely used, especially in connection with Dorr apparatus for removing inpurities from anthracite ranging from 5/16 to 3/64-in. size, reducing ash content from 40 per cent. in the feed to below 15 per cent. in the product, with capacity of 8 to 10 tons per hour per table. At the end of 1920 over 2500 tons was being so treated daily.

The Dorr apparatus, including the Hydroseparator, Dorr classifier and Dorr thickener, with and without tables, is finding very extensive application in recovering small sizes of coal, in displacing settling and draining tanks, and in water clarification. The pioneer work at the Loree anthracite breaker, referred to last year,[6] to recover fine coal from

[1] *Inst. Min. Eng.*, **60**, 243 (1920).
[2] D. C. Ashmead, *Coal Age*, **17**, 499 (1920).
[3] *Can. Min. Jour.*, **41**, 1055 (1920).
[4] D. C. Ashmead, *Coal Age*, **17**, 348, 754 (1920).
[5] J. H. McNally, *Coal Age*, **17**, 496; **18**, 1089 (1920).
[6] MINERAL INDUSTRY, **28**, 793 (1919).

sludge was continued to a point where 225 tons of coal was recovered per day by the use of Dorr Hydroseparator and Dorr classifier. The product contained 15 per cent. finer than 60 mesh and analyzed 25 to 40 per cent. ash. Tests by concentrating tables on this product showed that with feed analyzing 35 per cent. ash the table would make a product with 12 per cent. ash and containing about 65 per cent. of the coal in the table feed.

At the Drifton breaker a Dorr plant was installed to prevent stream pollution and the stream bed is now free from deposited coal solids. This plant handles about 2100 gal. per min. of breaker sludge carrying 8 per cent. solids. This will pass a $\frac{1}{16}$-in. round-hole screen and the recovered product contains most of the material coarser than 200 mesh. Installations in other plants are being made for the purpose of recovering and tabling all solids or for the purpose of recovering water from breaker sludge, either to prevent stream pollution or to supply water for breaker operations. Removal of over 90 per cent. of the solids will be effected. Some of the work of the Dorr apparatus on coal, with its economic aspect, has been described by J. Griffin.[1]

On bituminous coal two 70-ft. Dorr thickeners at the Risco washery, Palos, Ala., clarify the circulating water amounting to 3500 gal. per min. The feed contains 4 to 6 per cent. of solids and the overflow carries 0.15 per cent., being practically clear to be used again as wash-water on the jigs.

Continuous centrifugal driers have been developed to a point where they are in commercial operation, drying the product down to 5 to 7 per cent. moisture at the rate of over 2000 tons per machine per day and at a cost of 3 to 4 cts. per ton. For best results the feed should not contain over 15 per cent. moisture. The Wendell drier, which has automatic intermittent discharging gates, has been described by C. Wendell,[2] and the Elmore drier, which has a mechanical device for scraping off the dried product continuously has been described by H. C. Ray.[3] The latter handles 75 tons per hour and dries feed with 50 per cent. moisture down to 11 per cent., or 25-per cent. feed down to 8 per cent., or 12 to 15-per cent. feed down to 6 per cent.

Continuous vacuum filters are used abroad on coal sludge cleaned by flotation, and an American filter has been installed in the coal-testing plant of the Deister Concentrator Co. It is further reported that a Portland filter is included in the plans of a coal-washing plant to be constructed in the State of Washington.

[1] *Coal Age*, **17**, 349 (1920). *Coll. Guard.*, **120**, 731 (1920).
[2] *Coal Age*, **18**, 108 (1920).
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AFRICA

The following tables give the mineral production of various countries in Africa. Provisional figures or estimates are given in full-faced type; other figures are official.

MINERAL PRODUCTION OF ALGERIA (a)
(In metric tons)

Year.	Antimony Ore.	Copper Ore.	Gypsum.		Iron Ore.	Lead-Silver Ore.	Mercury.	Onyx.	Phosphate Rock.	Salt.	Zinc Ore.
			Crude.	Plaster.							
1908...	190	3,330	.....	25,500	943,424	10,626	1,556	300	452,060	25,215	94,398
1909...	163	67	.....	29,000	836,044	11,131	.....	200	345,385	17,817	81,852
1910...	4,475	112	.....	48,500	1,064,909	12,652	50	123	412,319	21,470	94,445
1911...	7,428	4,939	.....	51,760	1,025,643	17,909	.....	198	335,059	20,431	60,895
1912...	2,165	316	.....	54,400	1,225,625	24,516	.....	300	373,881	23,950	84,495
1913...	(c)582	13,164	700	50,399	1,349,000	13,953	18	168	377,934	26,969	82,256
1914...	1,947	1,090	.....	.....	1,180,943	25,986	.....	...	485,552	.....	81,961
1915...	9,022	*Nil.*	.....	.....	910,880	15,046	*Nil.*	...	225,871	1,875	16,796
1916...	28,473	1,098	.....	.....	1,042,865	23,731	32	...	380,211	3,910	28,973
1917...	16,800	.....	.....	.....	985,293	23,040	.....	...	202,539	.....	38,400
1918...	7,229	*Nil.*	.....	.....	902,465	13,060	15	...	189,419	.....	20,263
1919...	2,160	410	.....	.....	735,579	8,457	8	...	242,186	.....	13,268
1920(b)	2,966	601	.....	.....	1,114,438	12,804	0.2	...	334,704	.....	12,804

(a) From *Statistique de l'Industrie Minérale.* (b) Exports, *Echo des Mines.*

MINERAL PRODUCTION OF EGYPT (a)
(In metric tons)

Year.	Gold, Oz.	Gold, Value.	Lead and Zinc Ores.	Manganese Iron Ore.,	Nitrate Shale. (b)	Petroleum.	Phosphate Rock.	Talc.
1910.....	4,452	$92,023	.....	.....	.....	.....	2,397	.....
1911.....	5,068	104,756	.....	.....	.....	2,793	12,013	.....
1912.....	4,958	102,482	3,510	.....	4,939	27,962	70,918	.....
1913.....	4,602	95,123	7,156	.....	4,740	12,786	104,450	.....
1914.....	6,136	126,831	4,909	.....	3,370	99,680	71,945	.....
1915.....	7,096	146,674	2,988	.....	4,271	30,054	82,998	.....
1916.....	6,287	129,952	.....	.....	3,950	57,743	125,008	.....
1917.....	3,319	68,604	.....	.....	4,347	136,845	115,732	.....
1918.....	2,856	59,034	.....	27,498	4,520	281,885	31,147	137
1919.....	1,948	40,265	.....	48,734	3,940	224,300	29,365	.....

(a) Statistics furnished by the Department of Mines and Quarries, Egypt. (b) Partial production, complete returns not available.

MINERAL AND METALLURGICAL PRODUCTION OF RHODESIA (a)
(In metric tons)

Year.	Antimony.	Asbestos.	Chrome Ore.	Coal.	Copper.	Diamonds, Carats.
1909.....	.....	.....	.....	155,035	.....	.....
1910.....	.....	.....	.....	163,357	.....	.....
1911.....	.....	.....	.....	192,806	.....	.....
1912.....	.....	*Nil.*	70,376	196,082	.....	587
1913.....	.....	295	64,405	220,747	.....	998
1914.....	.....	493	48,983	317,029	*Nil.*	1,005
1915.....	.....	2,042	61,556	371,737	1,028	.....
1916.....	39	6,256	90,302	445,918	3,578	1,021
1917.....	15	9,716	74,137	557,792	3,974	619
1918.....	15	8,712	31,789	499,177	3,306	450
1919.....	*Nil.*	9,956	35,850	518,252	3,059	386
1920.....	11	19,126	61,239	587,806	3,159	243

Year.	Gold, Oz.	Gold, Value.	Iron Ore.	Lead.	Tungsten Ore.	Silver, Oz.
1909	623,388	$12,985,430	.....	875	.....	262,133
1910	609,956	12,657,791	.....	679	.....	217,633
1911	628,521	12,991,500	.....	579	.....	187,641
1912	642,807	13,174,058	.....	533	.....	176,532
1913	689,954	14,261,343	.....	296	.....	142,390
1914	854,480	17,423,087	.....	152	1	150,793
1915	915,029	18,603,973	.....	25	4	186,233
1916	930,356	19,321,155	5,931	*Nil.*	3	200,676
1917	822,863	17,008,573	5,375	*Nil.*	11	211,939
1918	631,358	12,905,849	6,454	*Nil.*	37	175,722
1919	593,222	12,162,557	2,540	*Nil.*	20	171,995
1920	552,497	11,400,113	*Nil.*	*Nil.*	17	158,982

(a) From Annual Report of the Rhodesia Chamber of Mines.

MINERAL PRODUCTION OF TUNIS (a)

(In metric tons)

Year.	Salt.	Lead Ore.	Phosphate of Lime.	Zinc Ore.	Year.	Iron Ore.	Lead Ore.	Phosphate of Lime.	Zinc Ore.
1905....	54,900	15,200	522,000	37,100	1912...	.....	51,300	2,050,000	37,400
1906 ...	62,600	14,800	796,000	32,400	1913(b)	594,199	52,200	2,170,500	30,300
1907 ...	78,200	18,600	1,069,000	22,800	1914...	529,170	39,105	1,395,630	16,800
1908....	149,600	37,500	1,300,500	26,500	1915...	297,134	21,320	1,170,033	4,550
1909....	118,400	41,600	1,300,000	24,500	1916...	500,935	51,286	1,041,204	12,544
1910....	199,700	(c)37,000	1,334,000	(c)32,500	1917...	605,958	41,391	576,600	14,853
1911. ..	.....	36,100	1,592,000	(c)27,900	1918...	455,022	30,963	821,145	5,508

(a) From *Statistique de l'Industrie Minérale.* (b) From *l'Echo des Mines.*

MINERAL AND METALLURGICAL PRODUCTION OF THE UNION OF SOUTH AFRICA (d)

Year.	Antimony.	Asbestos.	Coal.	Copper Matte. (a)	Corundum.	Diamonds. Carats.	Gold, Oz.	Gold, Value.	Graphite.	Gypsum.
1914.....	.....	1,209	8,614,417	29,797	12	2,801,016	8,396,068	$173,546,726	35	1,820
1915.....	90	2,172	8,414,653	29,436	69	103,385	9,096,410	188,022,795	42	2,884
1916.....	734	4,731	10,168,623	23,210	767	2,346,330	9,296,963	192,168,225	61	4,054
1917.....	627	6,320	10,549,783	20,499	2,671	2,902,417	9,018,389	186,424,300	87	2,116
1918.....	90	3,332	8,958,709	6,191	3,516	2,543,735	8,418,217	174,017,845	72	2,393
1919.....	29	3,568	9,309,558	4,450	162	2,592,099	8,331,651	172,100,703	78	*Nil.*
1920.....	*Nil.*	6,452	10,408,716	9,866	237	2,551,665	8,158,455	168,635,365	66	.....

Year.	Iron Pyrite.	Lead.	Lime.	Magnesite.	Mica.	Salt. (b)	Silver, Oz.	Soda (crude).	Talc.	Tin. (c)
1914.....	.....	138	67,159	582	.....	40,939	890,781	2,635	.....	3,484
1915.....	554	183	70,100	637	2	45,830	966,176	6,404	45	3,496
1916.....	5,362	409	79,481	619	13	57,173	968,935	6,400	134	3,317
1917.....	2,902	274	90,491	794	4	.....	938,146	5,808	798	2,731
1918.....	4,200	147	92,782	754	5	.....	877,498	694	608	2,021
1919.....	5,019	686	.....	928	3	.....	891,304	47	686	1,477
1920.....	3,147	532	.....	1,286	1	.....	892,205	*Nil.*	618	2,224

(a) About 45 per cent. copper. (b) Including by-products. (c) Concentrates, 67.5 per cent. tin. (d) Official statistics of the Department of Mines and Industries. The figures correspond to sales or shipments in the year indicated, rather than mine output; the figures are in metric tons except where otherwise stated.

AUSTRALASIA

In the following tables the production of minerals and metals in each of the Australian states and New Zealand is separately itemized. In the tables relating to foreign commerce, however, the states are not separately treated, the combined statistics of the Commonwealth now being officially reported. Figures in full-faced type are either provisional figures or estimates.

MINERAL PRODUCTION OF NEW SOUTH WALES (a)
(In metric tons or dollars; £1 = $5) (b)

Year.	Alunite.	Antimony and Ore.	Bismuth Ore.	Chrome Ore.	Coal.	Coke.	Cobalt Ore.	Copper Ore.
1906.....	1,886	2,490	25	15	7,748,384	189,038	*Nil.*	(g)
1907.....	2,021	1,780	17	30	8,796,451	258,683	*Nil.*	(g)
1908.....	1,099	119	9	*Nil.*	9,293,377	288,413	*Nil.*	(g)
1909.....	3,556	97	9	*Nil.*	7,132,548	207,553	*Nil.*	(g)
1910.....	1,154	99	7	*Nil.*	8,304,693	286,854	10	(g)
1911.....	1,023	168	9	*Nil.*	8,831,175	268,935	*Nil.*	(g)
1912.....	3,479	64	6	*Nil.*	10,044,487	245,050	*Nil.*	(g)
1913.....	2,269	18	9	*Nil.*	10,587,734	303,585	*Nil.*	(g)
1914.....	3,089	37	15	*Nil.*	10,557,911	309,677	*Nil.*	(g)
1915.....	1,443	646	18	*Nil.*	9,601,137	424,479	*Nil.*	(g)
1916.....	330	630	30	*Nil.*	8,258,008	444,632	*Nil.*	(g)
1917.....	1,817	306	5	596	8,431,081	436,180	*Nil.*	(g)
1918.....	.....	364	32	375	9,314,229	618,633	*Nil.*	*Nil.*
1919.....	2,525	8,827	20	254	8,770,522	431,612	*Nil.*	*Nil.*
1920.....	.....	.....	.....	.....	10,988,527	576,707	.....	.....

Year.	Copper Matte, Ingot, and Regulus.	Diamonds. *Carats.*	Gold. (b)	Lead, Argentiferous. (f)		Lead, Pig. (f)	Molybdenite.	Opal.
				Ore.	Metal. (e)			
1906....	9,911	2,827	$5,249,762	377,890	22,573	60	34	$282,500
1907....	10,260	2,539	5,112,852	441,024	20,687	20,084	22	395,000
1908....	9,215	2,205	4,646,451	364,488	(h)	15,174	9	209,000
1909....	7,078	5,474	4,231,211	273,628	(h)	15,724	29	309,000
1910....	13,096	3,606	4,011,055	322,780	(h)	21,534	50	331,000
1911....	12,295	5,771	3,743,672	343,902	(h)	17,552	21	286,500
1912....	11,211	2,239	3,416,560	350,850	(h)	17,528	57	170,349
1913....	9,619	5,573	3,093,331	397,783	(h)	23,947	80	143,513
1914....	6,713	1,580	2,573,496	342,411	(h)	26,405	62	132,670
1915....	7,085	839	2,738,677	287,329	(h)	30,793	33	32,015
1916....	6,270	1,901	2,235,357	253,872	(h)	25,876	55	106,365
1917....	6,685	2,991	1,698,517	238,795	(h)	21,164	71	62,610
1918....	6,619	1,784	1,801,287	.....	.....	.....	95	103,000
1919....	1,484	1,774	1,360,855	421,088	(h)	81,466	67	146,290
1920....	1,311	.....	1,010,908	.....	.....	.....	.....	.....

Year.	Platinum. Kg.	Oil Shale.	Silver. Kg.	Tin.		Tungsten Ore.	Zinc. (c) (f)
				Ore.	Block.		
1905.....	12.4	38,838	12,987	726	817	228	105,189
1906.....	6.4	32,965	8,865	(h)	1,698	245	105,325
1907.....	8.6	48,088	63,573	(h)	1,945	409	241,015
1908.....	4.2	47,044	77,490	(h)	1,822	247	281,147
1909.....	13.7	49,500	53,430	(h)	1,974	129	379,907
1910.....	10.3	69,385	55,176	(h)	1,898	168	476,125
1911.....	14.6	76,306	54,975	(h)	1,960	288	524,666
1912.....	19.0	87,399	74,314	(h)	2,107	231	528,872
1913.....	13.7	17,268	68,267	(h)	3,071	172	515,105
1914.....	7.6	50,880	89,318	(h)	2,355	200	365,059
1915.....	1.7	15,723	100,698	(h)	2,223	84	193,988
1916.....	2.6	17,706	87,139	(h)	2,163	268	213,118
1917.....	8.1	32,189	55,420	979	1,127	120	273,020
1918.....	18.9	32,935	.....	.....	.....	.....	353,403
1919.....	6.6	25,954	183,102	1,571	1,165	218	80,692

(a) From the Annual Report of the Department of Mines, New South Wales. (b) Where gold is reported, £1 = $4.866. (c) Spelter and concentrate. (d) Includes minor quantities of lead carbonate and chloride, the product of the leaching plant at Broken Hill. (e) Includes a small quantity of silver sulphide. (f) Exported. In the case of lead, 101,811 long tons was produced in 1912 from N. S. Wales in Australia. (g) Included with metal. (h) Included with ore.

MINERAL PRODUCTION OF QUEENSLAND (a)
(In metric tons or dollars; £1 = $5)

Year.	Bismuth Ore.	Coal.	Copper.	Gold. (b)	Lead.	Manganese Ore.
1906.....	7	610,480	10,238	$11,257,316	2,854	1,131
1907.....	6	694,204	12,959	9,641,789	5,240	1,134
1908.....	22	707,473	14,932	9,613,051	7,207	1,403
1909.....	11	768,720	14,727	9,416,576	5,323	613
1910.....	22	885,108	16,649	9,123,531	2,435	805
1911.....	10	905,568	20,709	7,981,791	1,799	1,167
1912.....	(c) 201	917,202	23,505	7,191,846	3,179	313
1913.....	(c) 185	1,045,243	24,050	5,492,585	3,663	27
1914.....	(c) 197	1,071,237	18,738	5,156,919	736	6
1915.....	(c) 253	1,041,003	89,318	5,303,515	494	203
1916.....	(c) 139	922,341	19,833	4,569,755	625	653
1917.....	(c) 137	1,065,353	19,370	3,706,135	489	21
1918.....	(c) 137	999,022	19,285	2,760,827	225	1,320
1919.....	(c) 144	946,630	10,158	2,501,625	137	20
1920.....	(c) 51	1,127,783	16,153	2,382,885	1,736	15

Year.	Molybdenite.	Opal.	Silver. Kg.	Tin Ore.	Tungsten Ore.
1906.....	108	$15,000	24,357	4,900	785
1907.....	68	15,000	28,662	5,222	627
1908.....	89	12,500	36,200	4,903	426
1909.....	94	10,000	31,140	3,379	617
1910.....	108	15,000	26,787	3,000	869
1911.....	(c)232	15,000	17,076	3,140	548
1912.....	104	14,600	17,712	3,284	636
1913.....	68	14,600	18,817	4,251	364
1914.....	79	9,700	7,899	2,119	245
1915.....	99	2,500	7,457	2,160	425
1916.....	83	2,500	7,561	1,734	376
1917.....	113	500	7,516	1,196	358
1918.....	112	1,500	4,743	1,333	253
1919.....	120	3,000	2,863	1,010	245
1920.....	29	2,500	8,528	1,510	84

(a) From *Annual Reports* of the Under Secretary of Mines, Queensland. (b) Where gold is reported, £1 = $4.866. (c) Includes bismuth and some tungsten.

MINERAL PRODUCTION OF SOUTH AUSTRALIA
(In metric tons or dollars) (a)

Year.	Copper.		Gold. (b)	Iron Ore.	Lead.	Lime-stone.	Phosphate Rock.	Salt.	Other Metals and Minerals.
	Ore.	Metal.							
1908.....	.....	5,718	$59,852	89,412	.....	29,973	11,177	76,204	$22,500
1909.....	1,250	5,788	146,982	16,379	142	13,986	3,833	52,232	19,355
1910.....	.....	5,184	136,248	46,939	406	18,898	5,283	54,862	68,000
1911.....	.....	6,017	72,990	42,976	.....	29,159	5,893	66,040	56,600
1912.....	.....	6,395	136,248	42,877	.....	51,412	6,198	65,338	51,044
1913.....	.....	7,174	134,275	61,669	.....	45,038	6,049	66,083	104,906
1914.....	.....	6,996	129,343	43,324	.....	54,955	6,184	66,083	179,425
1915.....	.....	7,851	125,689	241,252	.....	72,895	4,689	65,066	207,140
1916.....	.....	7,396	160,578	191,361	.....	75,843	5,094	67,469	142,331
1917.....	.....	7,329	147,605	333,673	.....	69,566	5,183	47,612	228,444
1918.....	.....	7,284	127,742	261,167	.....	73,372	8,204	89,944	470,966
1919.....	.....	2,557	66,645	272,853	.....	46,129	6,046	70,288	285,377
1920.....	.....	4,409	35,079	419,688	.....	30,999	8,894	72,012	398,559

(a) From *Mining Review*, Department of Mines, Adelaide, South Australia. (b) Where gold is reported, £1 = $4.866.

MINERAL PRODUCTION OF TASMANIA (a)
(In metric tons or dollars) (b)

Year.	Coal.	Copper Ore.	Blister Copper.	Gold. (b)	Iron Ore.	Lead-Silver Ore.	Tin Ore.
1907.....	59,833	1,261	8,378	$1,350,836	3,048	91,216	4,412
1908.....	62,044	1,204	8,974	1,179,950	3,657	62,022	4,593
1909.....	67,224	1,613	8,472	951,005	*Nil.*	81,668	4,583
1910.....	83,763	682	8,324	765,784	*Nil.*	52,047	3,760
1911.....	57,980	2,323	6,118	628,375	*Nil.*	62,489	4,016
1912.....	54,366	1,414	5,218	784,320	*Nil.*	91,570	3,773
1913.....	55,960	2,000	4,645	690,369	*Nil.*	84,677	4,077
1914.....	61,807	3,343	7,634	542,437	*Nil.*	11,758	2,616
1915.....	65,612	67	8,031	383,450	(e)13,049	10,556	2,642
1916.....	56,470	98	6,406	326,372	(e)14,230	11,410	2,901
1917.....	64,433	784	5,922	299,634	(c) 7,809	9,730	2,680
1918.....	61,132	451	5,648	217,627	(c) 5,188	7,358	2,292
1919.....	67,320	.....	5,108	157,875	(c) 3,457	2,396	1,605
1920.....	76,643	.....	4,869	129,109	(c) 4,511	3,918	1,331

(a) From *Statistics of the Colony of Tasmania*. (b) Where value of gold is reported, £1 = $4.866. (c) Included with lead-silver ore. (d) Not reported. (e) Iron pyrite.

MINERAL PRODUCTION OF NEW ZEALAND (a) (b)
(In metric tons or dollars) (c)

Year.	Anti-mony.	Coal.	Coke.	Copper Ore.	Gold. (c)	Kauri-gum.	Manga-nese Ore.	Silver. Kg.	Tung-sten Ore.
1908...	5	1,890,844	2	13	$9,755,303	5,618	*Nil.*	53,834.8	69
1909...	2	1,941,923	23	5	9,765,575	8,382	6	56,410.0	59
1910...	*Nil.*	2,232,610	*Nil.*	*Nil.*	9,227,532	8,832	5	52,176.8	145
1911...	20	2,099,234	*Nil.*	*Nil.*	9,105,000	7,587	1	40,775.2	140
1912...	.....	2,177,615	4	*Nil.*	6,427,422	7,908	.....	24,237.8	137
1913...	.....	1,919,472	28	.....	7,101,822	8,926	.....	30,344.6	225
1914...	*Nil.*	2,313,519	17	3	4,356,856	8,581	*Nil.*	18,636.4	207
1915...	*Nil.*	2,244,183	24	*Nil.*	8,245,695	4,650	*Nil.*	29,782.4	197
1916...	*Nil.*	2,293,475	34	*Nil.*	5,835,366	5,536	*Nil.*	24,479.7	270
1917...	*Nil.*	2,101,721	121	6	4,398,319	4,668	*Nil.*	24,482.8	164
1918...	13	2,067,001	71	*Nil.*	206,275	2,458	*Nil.*	27,351.4	172
1919...	*Nil.*	1,877,598	46	*Nil.*	6,493,215	4,194	*Nil.*	14,107.3	133
1920...	*Nil.*	1,873,389	20	*Nil.*	4,300,318	6,951	2	11,489.5	11

(a) From New Zealand Mines Statement, by the Hon. Roderick McKenzie, Minister of Mines, Wellington. (b) The exports are stated to be identical with the production, with the exception of coal (c) Where gold is reported, £1 = $4.866.

MINERAL PRODUCTION OF VICTORIA (a)
(In metric tons or dollars)

Year.	Antimony Ore.	Coal.	Lignite.	Gold. (c)	Building Stone, etc. (b)	Tin Ore.
1906.....	208	163,201	*Nil.*	$15,962,804	$1,705,420	108
1907.....	4,575	140,802	*Nil.*	14,377,166	2,023,130	105
1908.....	3,740	115,283	*Nil.*	13,867,312	2,138,070	80
1909.....	1,779	130,230	*Nil.*	13,522,400	2,226,220	90
1910.....	1,283	374,775	660	11,789,077	2,542,815	42
1911.....	1,116	664,326	6,232	11,789,077	2,820,800	33
1912.....	2,470	598,599	4,076	9,924,032	3,385,070	48
1913.....	6,253	603,811	3,034	9,189,593	3,261,815	58
1914.....	7,730	627,828	2,760	8,540,978	3,485,880	54
1915.....	11,113	588,104	2,864	6,794,771	3,361,662	96
1916.....	12,581	423,900	2,962	5,304,884	.....	124
1917.....	2,613	473,726	39,774	3,172,595	3,171,274	141
1918.....	1,201	439,575	66,200	3,242,797	4,246,125	135
1919.....	1,208	423,946	111,628	2,799,215	4,743,737	113
1920.....	961	442,241	162,682	3,157,883	.....	85

(a) From Annual Reports of the Secretary for Mines of the Colony. (b) Includes bricks, tiles, pottery and salt. (c) Where gold is reported, £1 = $4.866.

MINERAL PRODUCTION OF WESTERN AUSTRALIA (a)
(In metric tons or dollars)

Year	Tungsten Ore.	Coal.	Copper Ore.	Copper and Matte.	Gold. (b)	Iron Ore.	Lead Ore. (g)	Silver. *Kg.*	Tin Ore.
1909.....	1	217,741	7,071	846	$32,973,349	*Nil.*	(d) 214	5,500	(e) 703
1910.....	2	266,361	6,410	1,301	30,397,162	10	252	5,478	509
1911.....	10	253,900	9,974	832	28,331,272	*Nil.*	1,575	5,215	502
1912.....	*Nil.*	299,815	9,689	28	26,511,841	*Nil.*	1,898	5,144	666
1913.....	(g)1	319,048	(g)4,411	(g)83	27,160,557	*Nil.*	(d)3,222	5,848	(h)496
1914.....	(g)0.5	324,530	(g)3,978	(g)186	25,484,960	*Nil.*	(d)3,642	6,005	(gh)368
1915.....	(g)0.3	291,281	(g)749	(g)961	25,012,349	*Nil.*	(d)2,929	6,909	(gh)436
1916.....	(g)1	306,381	(g)660	(g)464	21,938,516	*Nil.*	(d)435	5,381	(gh)470
1917.....	*Nil.*	331,807	(g)982	(g)544	20,055,935	*Nil.*	(d)22	6,907	(gh)390
1918.....	5	342,465	(g)1,669	(g)486	18,117,482	*Nil.*	287	3,416	422
1919.....	6	408,181	(g)462	(g)4	15,172,738	*Nil.*	252	6,946	323

(a) From the *Report of the Department of Mines of Western Australia.* (b) £1 = $4.866. (d) Silver-lead and lead ore. (e) Includes ingots. (f) Total in previous years. (g) Exports. (h) Ore and ingot.

MINERAL IMPORTS OF AUSTRALIA (a)
(In metric tons, cwt. of 112 lb., or dollars; £1 = $5) (b)

Year.	Cement. *Cwt.*	Coal.	Coke.	Copper Ore. *Cwt.*	Gold. (b)				
					Ore.	Bullion.	Specie.	Foil. (c)	Total Value.
1910	1,612,004	314,393	17,161	23,027	$35,712	$4,653,044	$126,556	.....	$4,815,312
1911	1,670,117	10,498	22,608	10,201	62,951	7,707,919	124,248	.....	7,895,118
1912	2,603,792	16,152	15,839	18,449	93,885	5,478,177	1,190,890	.....	6,762,952
1913	2,511,828	4,928	27,304	25,085	118,263	5,699,945	910,064	.....	6,728,272
1914(e)	1,040,494	14,085	10,887	11,736	71,311	2,670,213	973,200	.....	3,714,724
1915(f)	1,407,099	13,580	15,852	14,037	112,035	2,105,421	16,773	.....	2,234,229
1916(f)	1,516,858	6,186	1,734	16,257	162,529	2,648,749	32,179	.....	2,843,457
1917(f)	150,025	56,081	312	28,974	168,558	962,279	(c)	.....	1,130,837
1918(f)	11,017	32,888	*Nil.*	9,448	126,034	6,016,245	1,216,500	.....	7,358,779
1919(f)	372	57,770	*Nil.*	18,718	76,854	35,835,428	740	.....	35,913,022
1920(f)	112,739	35,765	4	3,380	39,726	238,293	92	.....	278,111

Year.	Graphite.	Iron and Steel.			Lead Mfrs. *Cwt.*	Petroleum Products.		
		Bars, Rods Girders, Sheets, etc. *Cwt.*	Galvanized Plates and Sheets. *Cwt.*	Pig and Scrap. *Cwt.*		Kerosene. *Gal.*	Benzine, Gasoline, etc. *Gal.*	Paraffin.
1910...	$49,755	3,663,386	(*d*)2,131,911	1,073,933	9,111	19,660,890	1,339,381	3,963
1911...	38,910	4,215,986	(*d*)2,177,961	1,574,439	2 120	19,378,540	1,772,840	3,321
1912...	43,145	4,933,414	(*d*)2,416,367	1,719,585	955	24,292,539	12,294,617	2,832
1913...	48,925	5,070,590	(*d*)2,196,865	1,535,030	2,075	19,288,122	9,812,771	2,803
1914 (*e*)	26,595	2,377,790	(*d*)1,265,429	833,008	7,676	12,231,752	8,853,386	1,815
1915 (*f*)	41,795	3,236,889	1,676,033	1,352,011	2,650	20,444,196	12,446,797	2,790
1916 (*f*)	61,135	3,219,064	1,238,623	631,133	1,208	24,857,800	16,722,829	4,547
1917 (*f*)	44,246	2,020,416	452,590	376,515	426	22,626,762	20,412,125	2,463
1918 (*f*)	30,340	557,189	259,717	48,311	374	14,060,462	17,088,779	3,370
1919 (*f*)	33,970	885,408	562,823	24,949	277	16,672,962	20,748,976	3,361
1920 (*f*)	35,327	1,341,995	1,247,532	72,823	365	15,625,778	24,891,031	4,667

Year.	Potassium Nitrate. *Cwt.*	Quick-silver.	Salt. *Cwt.*	Silver. (*b*)			Sulphur. *Cwt.*	Zinc, Bar and Sheet. *Cwt.*
				Ore. *Cwt.*	Bullion. *Kg.*	Specie.		
1910.....	7,016	57.6	444,081	14,609	1,411.7	$1,615,775	357,332	70,339
1911.....	10,257	42.4	753,849	1,734	1,115.8	1,648,430	386,764	86,362
1912.....	10,127	52.8	468,507	3,836	1,580.3	1,350,870	465,643	61,736
1913.....	10,552	46.0	533,055	10,396	1,180.4	861,500	603,865	41,650
1914(*e*)...	6,349	20.9	139,024	.....	622.5	546,481	246,586	21,147
1915(*f*)...	7,500	24.0	372,160	319	586.1	2,062,386	421,497	29,193
1916(*f*)..	7,522	34.0	270,475	.....	174.2	1,068,988	825,648	12,303
1917(*f*)..	3,421	15.5	78,578	.....	143.0	218,814	991,780	3,743
1918(*f*)..	5,926	32.3	56,785	.....	15,558	251,728	792,904	4,775
1919(*f*)..	9,542	12.0	37,471	.....	11,848	120,482	592,063	4,449
1920(*f*)..	5,155	23.6	77,984	.....	428.2	39,688	678,017	5,966

(*a*) From Trade and Customs Returns, Commonwealth of Australia. Previous to 1900 each Colony reported its own imports and exports. (*b*) Where gold or silver values are reported, £1 = $4.866. (*c*) Included with bullion. (*d*) Includes ungalvanized corrugated. (*e*) First six months. (*f*) Fiscal year ending June 30th.

MINERAL EXPORTS OF AUSTRALIA (*a*)

(In metric tons, cwt. of 112 lb., or dollars; £1 = $5)

Year.	Alunite. *Cwt.*	Anti-mony Ore. *Cwt.*	Bis-muth Ore. *Cwt.*	Cement. *Cwt.*	Chrome Ore. *Cwt.*	Coal.	Coke.	Co-balt Ore. *Cwt.*	Copper.	
									Ore.(*f*) *Cwt.*	Ingot and Matte. (*Cwt.*)
1910...	23,290	12,796	1,456	34,259	.....	1,730,473	10,457	186	260,597	765,176
1911...	20,274	17,985	2,307	45,247	.....	1,714,959	8,543	.....	264,688	806,005
1912...	68,500	30,894	610	27,724	453	2,186,946	9,852	.....	259,690	876,773
1913...	44,700	51,007	588	18,221	.....	2,132,201	8,163	.....	177,757	846,411
1914(*g*)	24,200	30,661	151	23,813	.....	1,182,548	2,636	.....	62,658	392,005
1915(*h*)	52,400	50,316	1,295	24,591	.....	1,394,151	14,563	.....	142,363	669,189
1916(*h*)	12,800	74,631	2,602	27,345	.....	944,931	25,658	.....	89,382	737,841
1917(*h*)	6,500	51,995	1,883	15,406	.....	656,961	35,286	.....	602	721,785
1918(*h*)	.....	10,601	1,864	21,384	.....	362,466	37,901	.....	.....	541,416
1919(*h*)	6,400	29,039	477	32,914	.....	536,573	34,725	.....	.....	420,072
1920(*h*)	29,400	68,998	4,471	45,573	.....	1,029,649	34,766	.....	2,164	548,268

Year.	Gold. (b)				Iron and Steel Bars, Rods, Girders, Sheet, etc. *Cwt.*	Lead.		
	Ore.	Bullion. (e)	Specie.	Total Value.		Pig. *Cwt.*	Contained in Matte. *Cwt.*	Manufactures. *Cwt.*
1910....	429,288	$12,070,522	$16,598,747	$23,098,557	154,846	1,326,702	473,556	13,350
1911....	327,107	10,456,322	47,831,267	58,614,696	116,893	1,358,308	397,342	14,610
1912....	340,474	9,135,487	50,801,322	60,277,283	138,061	1,438,681	502,264	17,916
1913....	371,257	6,695,757	10,184,007	17,251,021	184,433	1,529,075	524,513	14,989
1914 (g).	45,825	2,119,722	4,882,690	7,048,235	71,337	676,457	376,587	10,239
1915 (h).	255,883	3,325,439	9,447,081	13,028,403	179,122	1,427,455	737,416	14,190
1916 (h).	125,144	5,053,472	46,308,413	51,487,029	221,548	1,636,974	821,160	10,868
1917 (h).	4,705	1,735,288	54,768,149	56,503,437	269,013	2,372,935	548,880	14,895
1918 (h).	.....	162,880	30,950,320	31,113,210	80,307	1,904,856	311,659	23,366
1919 (h).	.....	10,374	10,815,819	10,826,193	352,245	2,071,721	.....	29,772
1920 (h).	.....	1,104,718	25,892,244	26,996,962	595,904	1,480,602	16,365	13,925

Year.	Molybdenum Ore. *Cwt.*	Salt. *Cwt.*	Shale, Oil.	Silver.		Tin.		Zinc, Bar and Sheets. *Cwt.*
				Ore. (d) *Cwt.*	Bullion. (e) *Kg.*	Ore. *Cwt.*	Block. *Cwt.*	
1910.....	1,972	184,892	9,307	$ 2,520,652	233,494	($)48,209	87,529	1,807
1911.....	1,876	63,607	6,344	$ 3,226,043	218,387	($)55,721	82,935	1,050
1912.....	2,873	123,779	290	$ 2,395,267	238,947	($)64,704	77,501	15,971
1913.....	2,684	134,863	449	$ 3,377,901	252,219	($)89,384	68,392	12,236
1914 (g)..	2,009	47,560	283	$ 1,701,932	126,139	($)42,616	27,624	.....
1915 (h)..	2,080	111,001	457	$ 553,173	213,102	($)42,845	29,891	54,099
1916 (h)..	2,569	312,525	20	$ 195,565	205,019	($)48,111	68,690	46,132
1917 (h)..	3,525	244,377	19	$ 61,713	174,524	39,931	61,085	43,325
1918 (h)..	3,341	316,234	.....	$	162,168	3,806	73,199	15,363
1919 (h)..	4,007	256,118	5	$	355,826	.....	64,038	56,246
1920 (h)..	4,573	217,132	.....	$ 42,878	148,168	.....	68,131	35,636

(a) From Trade and Customs Returns, Commonwealth of Australia.—Note. Previous to 1900 each Colony reported its own exports separately. (b) Where gold or silver values are reported, £1 = $4.866. (c) Included with iron ore. (d) Includes lead ore. (e) Includes that contained in matte. (f) Includes concentrates. (g) First six months. (h) Fiscal year ending June 30th. (i) Silver-lead bullion.

AUSTRIA-HUNGARY

In the following tables the mineral and metal productions of the two Kingdoms are reported separately, together with that of Bosnia and Herzegovina. Exports and imports are reported jointly.

MINERAL AND METALLURGICAL PRODUCTION OF AUSTRIA (a)
(In metric tons)

Year.	Alum.	Alum and Pyritic Shale.	Antimony.		Asphalt and Asphaltic Rock.	Bismuth Ore.	Coal.	
			Ore.	Metal.			Bituminous.	Lignitic.
1900	620	3,004	201	153	924	4.0	10,992,515	21,539,917
1901	442	2,551	126	114	561	16.0	11,738,840	22,473,510
1902	62	2,866	18	24	927	8.0	11,045,039	22,139,683
1903	*Nil*	2,978	41	14	1,298	9.7	11,498,111	22,157,521
1904	*Nil*	2,337	103	36	1,435	1.7	11,868,245	21,987,651
1905	*Nil*	1,657	1,673	90	4,363	1.7	12,585,263	22,692,076
1906	*Nil*	1,020	1,071	*Nil*	2,840	2.7	13,473,307	24,167,714
1907	*Nil*	*Nil*	910	207	3,858	*Nil*	13,850,420	26,262,110
1908	*Nil*	*Nil*	193	162	3,695	*Nil*	13,875,382	26,728,926
1909	*Nil*	*Nil*	450	*Nil*	2,975	*Nil*	13,713,043	26,043,716
1910	*Nil*	*Nil*	225	*Nil*	1,066	*Nil*	13,773,985	25,132,855
1911	*Nil*	*Nil*	270	.....	1,740	.....	14,379,817	25,265,334
1912	.....	.....	4,520	13	4,234	.....	15,797,890	26,283,690
1913	.....	.....	1,270	.....	3,026	.....	16,459,889	27,378,332

Year.	Copper.			Copperas.	Gold.		Graphite.	Iron.	
	Ore.	Metal.	Sulphate.		Ore.	Bullion.		Ore.	Pig & Cast.
1900	5,825	881	234	474	227	$47,183	33,663	1,894,458	1,000,207
1901	7,406	776	256	472	143	31,234	29,992	1,963,246	1,030,260
1902	8,455	914	248	271	74	4,652	29,527	1,744,498	991,827
1903	8,188	961	310	298	2,148	5,316	29,590	1,715,984	970,832
1904	10,701	889	808	414	12,653	47,183	28,620	1,719,219	988,364
1905	10,677	870	540	116	35,937	133,218	34,416	1,913,782	1,119,614
1906	20,255	877	578	154	33,033	83,401	38,117	2,253,662	1,222,230
1907	10,400	592	579	*Nil*	30,711	92,471	49,425	2,540,118	1,383,524
1908	8,381	683	556	*Nil*	28,907	98,504	44,425	2,632,407	1,466,897
1909	11,826	985	591	70	29,709	98,295	40,710	2,490,277	1,465,051
1910	8,005	1,468	715	30	31,744	118,895	33,131	2,627,513	1,504,786
1911	10,974	1,760	767	*Nil*	29,647	134,840	41,599	2,765,815	1,596,148
1912	17,354	3,057	884	40	30,192	134,543	45,375	2,926,686	1,759,850
1913	16,353	3,685	897	40	35,994	186,714	49,456	3,039,324	1,757,864

Year.	Lead.			Manganese. Ore.	Mineral Paint.	Petroleum.	Quicksilver.		Salt.
	Ore.	Pig.	Litharge.				Ore.	Metal.	
1900	14,314	10,650	1,288	8,804	2,828	347,213	94,727	510	330,277
1901	16,688	10,161	1,317	7,796	1,701	404,662	97,360	525	333,238
1902	19,055	11,264	1,023	5,646	1,486	520,845	90,040	511	311,806
1903	22,196	12,162	923	6,179	1,691	672,508	83,321	523	359,015
1904	22,514	12,645	783	10,189	1,829	823,943	88,279	536	369,877
1905	23,339	12,968	865	13,788	798	794,391	86,856	520	343,375
1906	19,683	14,846	1,059	13,402	943	737,194	91,494	526	376,212
1907	22,792	13,598	863	16,756	1,091	1,725,808	89,370	527	395,053
1908	21,513	12,669	1,010	16,656	475	1,718,030	90,145	572	388,133
1909	20,550	12,941	840	18,045	620	2,086,342	92,337	585	359,801
1910	22,841	15,476	602	15,694	698	1,766,018	100,899	603	345,629
1911	23,845	18,097	318	15,954	2,902	1,487,842	111,018	704	342,732
1912	27,952	19,993	301	12,471	2,960	1,144,133	117,780	763	365,789
1913	25,751	22,312	305	16,540	2,999	1,081,090	130,608	820	337,563

Year.	Silver.		Sulphuric Acid.	Sulphur. Ore.	Tin.		Tungsten Ore.	Uranium.		Zinc.	
	Ore.	Bullion. *Kg.*			Ore.	Block.		Ore.	Salts.	Ore.	Spelter.
1900.	21,641	39,572	7,067	862	51	40	50	52.0	11.3	38,243	6,742
1901.	21,363	40,205	7,073	4,911	42	49	45	48.0	13.0	36,072	7,558
1902.	22,288	39,544	8,781	3,721	47	50	45	46.0	10.0	31,927	8,309
1903.	21,958	39,812	9,105	4,475	57	34	49	45.0	5.8	29,544	8,949
1904.	21,948	39,032	8,742	6,288	77	38	52	17.0	11.4	29,226	9,159
1905.	21,047	38,453	1,007	8,407	52	53	59	16.0	13.9	29,983	9,326
1906.	21,944	38,940	745	15,125	55	42	56	16.0	10.3	32,037	10,804
1907.	22,636	38,742	*Nil*	24,099	53	47	44	11.0	11.2	31,970	11,208
1908.	22,241	39,867	*Nil*	17,429	68	39	37	9.0	8.4	31,266	12,770
1909.	21,102	39,002	*Nil*	12,725	36	52	39	18.0	10.2	33,955	11,688
1910.	23,629	49,692	.....	15,839	37	40	40	6.5	10.3	34,637	12,458
1911.	24,143	50,244	.....	15,805	944	15	45	5.8	6.8	32,166	15,766
1912.	21,794	49,355	.....	13,996	606	13	66	11.0	5.4	34,675	17,298
1913.	19,937	54,434	.....	10,561	939	11	52	11.2	4.5	34,225	19,508

(a) From the *Statistisches Jahrbuch des K. K. Ackerbau-Ministeriums.*

MINERAL AND METALLURGICAL PRODUCTION OF HUNGARY (a)

(In metric tons or dollars; 1 crown = $0.203)

Year.	Antimony.		Asphalt	Asphaltic Rock.	Bismuth.	Carbon Bisulphide.	Coal.			
	Ore.	Regulus.					Bituminous. (d)	Lignite. (d)	Coke.	Briquets.
1901...	(b) 323	706	2,878	25,161	1.6	2,087	1,365,270	5,179,829	10,975	40,182
1902...	(b) 748	683	2,774	24,873	0.9	2,320	1,162,785	5,132,053	8,204	88,069
1903...	(b) 205	732	2,422	21,552	1.5	2,357	1,233,410	5,271,781	9,442	101,197
1904...	1,080	1,007	2,221	17,660	0.9	2,512	1,155,320	5,519,349	5,103	103,481
1905...	949	756	173	19,372	1.4	2,760	919,193	6,015,452	69,303	144,697
1906...	1,807	954	4,111	34,664	2.0	2,756	1,103,529	6,229,712	79,930	151,657
1907...	2,035	841	3,920	33,096	0.4	2,950	1,038,819	6,408,322	97,447	154,783
1908...	1,316	670	4,818	72,972	(c)	2,966	982,017	7,034,499	141,954	109,178
1909...	1,971	695	5,054	.....	.....	3,086	1,397,424	7,658,719	157,415	117,594
1910...	1,939	782	4,994	.....	.....	3,245	1,302,103	7,734,166	156,048	108,873
1911...	2,616	892	3,861	.....	.....	3,488	1,290,182	8,154,560	145,104	118,412
1912...	8,380	859	4,460	.....	.....	3,692	1,302,405	8,287,871	149,913	118,505
1913...	11,017	1,048	3,025	45,860	(f)25	3,148	1,319,918	8,954,133	160,073	117,186
1914...	.....	.....	.....	.....	.....	.....	909,882	.....	128,118	112,040

Year.	Copper.	Copperas.	Gold.	Iron.			Lead.		Litharge.	Manganese. Ore.
				Ore. (d)	Pig.	Cast.	Ore.	Pig.		
1901...	162	805	$2,189,692	1,557,300	430,686	20,640	(b) 10	2,029	238	4,591
1902...	89	909	2,260,135	1,562,238	416,835	18,569	(b) 20	2,244	219	7,237
1903...	45	982	2,243,521	1,439,132	396,674	18,875	(d)3,698	2,057	257	5,311
1904...	63	1,277	2,437,988	1,524,036	370,297	17,203	(d)3,922	2,104	710	11,527
1905...	73	920	2,439,451	1,661,358	403,719	17,563	686	2,146	209	5,708
1906...	69	1,306	2,487,156	1,698,291	402,527	17,164	564	1,925	698	7,176
1907...	85	1,212	2,330,292	(e)622,518	423,134	17,103	8	1,468	441	8,198
1908...	166	1,372	2,189,801	(e)727,019	505,559	17,415	3	1,544	190	10,601
1909...	265	1,414	1,813,024	1,965,487	514,853	15,577		1,590	625	11,921
1910...	214	1,313	2,022,032	1,905,749	487,421	14,635	91	2,077	570	13,270
1911...	208	849	2,125,241	1,950,231	502,460	15,990	239	1,583	391	14,755
1912...	242	1,364	1,898,771	1,991,162	541,659	11,180	1,212	1,605	477	13,833
1913...	405	627	1,945,958	2,059,076	608,966	13,986	488	1,137	412	19,006
1914...	358	.....	.....	1,722,340	494,441	.....	.....	1,368	.....	11,413

Year.	Mineral Paints.	Petroleum.	Pyrite.	Quicksilver. Kg.	Salt.	Silver. Kg.	Sulphur.	Sulphuric Acid.	Zinc.	
									Ore.(b)	Spelter.
1902...	283	4,347	106,490	44,600	217,079	23,020	105	1,193	364	.....
1903...	263	3,010	96,619	43,700	214,536	19,281	135	1,543	46	26
1904...	273	2,134	97,148	45,169	230,943	16,352	143	1,329	203	.....
1905...	196	471	106,848	36,000	238,642	15,946	135	1,410	173	.....
1906...	221	2,692	112,623	50,100	245,402	13,642	133	1,457	243	146
1907...	259	2,404	99,503	40,400	(c)	12,695	(c)	1,232	(c)	(c)
1908...	294	2,427	95,824	78,000	(c)	12,612	144	1,444	135	(c)
1909...	63	2,590	98,971	71,500	231,182	10,932	131	1,307	(0)	.....
1910...	55	2,501	92,464	90,000	230,315	12,547	128	1,334	280	.....
1911...	69	2,191	96,755	79,700	239,006	10,806	51	938	106	.....
1912...	105	2,793	103,809	84,979	270,929	10,782	83	1,311	778	.....
1913...	57	2,105	106,629	88,800	256,448	8,696	42	555	407	.....
1914...	.....	.....	102,370	85,050	.....	.....	.....	.....	.....	.....

(a) From the *Annuaire Statistique Hongrois.* (b) Includes only that part of the crude output that was not smelted into a refined product. (c) Not reported. (d) Total production. (e) Exported. (f) Kilograms.

MINERAL AND METALLURGICAL PRODUCTION OF BOSNIA AND HERZEGOVINA (a)

(In metric tons)

Year.	Chrome Ore.	Copper.		Iron.		Lignite.	Manganese Ore.	Pyrite.	Quicksilver.	Salt.
		Ore.	Metal.	Ore.	Pig.					
1902...	270	3,657	166	133,348	43,992	424,753	5,760	5,170	7.2	17,348
1903...	147	1,073	191	114,059	39,833	467,962	4,538	6,589	8.1	18,459
1904...	279	640	115	127,297	47,678	483,617	1,114	10,412	8.1	18,021
1905...	186	670	39	122,540	43,074	540,237	4,129	19,045	10.0	(b)
1906...	320	765	25	136,513	45,660	594,172	7,651	11,347	5.1	22,671
1907...	310	245	*Nil.*	150,684	48,946	621,179	7,000	7,229	1.2	21,148
1908 (c)	315	(b)	*Nil.*	150,075	48,900	630,500	6,000	(b)	*Nil.*	22,100
1909 (c)	310	(b)	*Nil.*	145,200	48,850	675,400	5,000	(b)	*Nil.*	22,500
1910...	320	(b)	*Nil.*	132,720	48,841	706,659	4,000	571	*Nil.*	23,579
1911...	250	(b)	*Nil.*	140,283	44,354	769,763	3,600	3,118	*Nil.*	22,591
1912...	200	.....	*Nil.*	150,420	53,270	852,920	4,650	6,216	*Nil.*	23,124
1913...	305	.....	.....	220,131	53,587	841,140	4,700	7,701	.....	24,176
1914...	211	.....	.....	178,830	44,078	806,831	4,120	4,459	.....	25,730

(a) From *Oestr. Zeit. f. B.-u. H.* (b) Not reported. (c) Estimated.

MINERAL IMPORTS OF AUSTRIA-HUNGARY (a)

(In metric tons or dollars; 5 Crowns = $1)

Year.	Alum.	Aluminium and Alloys.	Aluminium Sulphate and Chloride.	Antimony.		Arsenic. (b)	Asbestos.	
				Ore.	Regulus. Kg.		Crude. (c)	Manufactures.
1900.....	430	154	1,435	46	23,000	320	1,085	1,238
1901.....	413	153	1,882	27	1,500	351	1,678	1,032
1902.....	537	151	2,161	40	18,200	351	2,038	798
1903.....	508	150	2,670	42	87,200	371	3,395	1,221
1904.....	602	231	2,346	64	21,000	384	2,517	1,240
1905.....	774	477	2,775	42	24,700	342	5,962	208
1906(f)..	513	216	2,840	79	38,900	83	7,025	111
1907.....	545	255	3,200	231	89,900	325	5,729	180
1908.....	567	323	2,606	304	128,200	349	9,484	139
1909.....	359	418	1,831	95	80,100	370	12,003	200
1910.....	589	303	1,474	96	121,800	416	11,602	250
1911.....	375	516	1,317	98	124,600	377	16,071	276
1912.....	253	1,224	1,396	91	49,000	24	24,615	338
1913.....	454	589	1,334	.....	.....	47	17,575	248

Year.	Asphalt.		Barytes.	Borax.		Cement.	Chloride of Lime.	Chrome Ore.
	Crude Rock.	Mastic and Bitumen.		Crude, and Boric Acid.	Refined.			
1900.....	8,301	1,564	5,945	3,056	93	25,747	3,326	2,823
1901.....	5,702	1,106	6,336	1,687	233	23,559	3,326	860
1902.....	5,732	1,273	6,266	2,168	174	18,658	2,596	2,668
1903.....	5,871	1,272	7,057	2,192	150	23,256	2,791	2,121
1904.....	8,211	1,064	6,238	2,752	142	20,259	3,407	1,209
1905.....	8,553	1,139	6,187	3,099	205	21,950	1,847	2,305
1906(f).....	13,381	895	9,654	3,519	126	21,833	2,491	1,612
1907.....	9,394	1,637	11,669	3,763	138	23,697	2,534	2,795
1908.....	11,678	1,305	11,241	4,105	158	39,135	2,395	1,837
1909.....	9,113	1,309	13,940	3,240	139	53,262	3,105	2,223
1910.....	15,897	1,101	21,486	5,284	166	81,251	1,885	1,271
1911.....	18,394	1,990	20,501	4,407	193	80,613	3,131	2,217
1912.....	25,111	4,295	21,375	4,286	482	83,630	2,802	4,329
1913.....	24,794	1,011	23,350	5,652	356	61,261	3,097	2,845

Year.	Kaolin and Feldspar.	Coal.		Coke.	Copper.			Copper Sulphate
		Bituminous.	Lignitic.		Ore.	Bullion and Scrap.	Bars, Sheets, Wire, etc.	
1900.....	6,847	6,242,939	67,740	620,776	16	18,970	121	3,516
1901.....	7,687	5,827,332	22,253	612,209	112	17,504	83	2,822
1902.....	9,085	5,766,377	29,601	547,406	100	18,498	149	2,839
1903.....	9,940	5,907,660	30,007	519,281	209	18,701	89	3,526
1904.....	10,854	6,190,030	30,001	548,272	1,107	22,532	89	4,508
1905.....	13,656	6,418,042	36,000	554,147	1,397	22,652	73	3,791
1906(f)...	13,219	5,942,897	17,464	406,088	267	20,943	481	1,597
1907.....	17,961	9,692,645	23,699	677,750	44	26,181	818	3,981
1908.....	17,417	9,995,415	30,433	851,099	121	33,270	1,140	8,402
1909.....	16,185	10,482,264	38,679	701,281	13	30,606	568	4,129
1910.....	17,817	9,864,462	37,867	670,089	49	32,217	926	3,445
1911.....	22,828	10,873,799	34,381	702,707	716	37,251	538	6,598
1912.....	24,628	11,848,535	34,871	(h)915,547	765	45,460	850	16,131
1913.....	22,467	13,689,149	33,097	933,669	150	36,451	572	6,937

Year.	Copperas.	Cryolite.	Fluorspar.	Gold. (d)		Graphite.	Gypsum.		Hydrochloric Acid.
				Bullion.	Coin.		Crude.	Burned.	
1900.....	343	342	5,649	$1,111,831	$7,230,251	302	1,348	15,462	577
1901.....	269	428	5,774	13,865,103	20,353,592	318	1,405	15,830	576
1902.....	274	447	5,902	14,509,019	15,695,960	221	1,588	16,430	588
1903.....	155	521	5,445	9,825,200	9,817,283	405	1,969	18,655	603
1904.....	238	313	7,061	12,703,740	8,586,394	423	2,384	19,387	459
1905.....	169	220	7,601	1,047,792	9,204,968	735	1,553	21,286	656
1906(f)..	186	217	7,795	989,604	5,229,591	854	4,104	10,308	476
1907.....	187	613	8,779	1,106,002	5,755,918	934	5,813	11,981	629
1908.....	74	564	7,359	7,303,982	7,969,538	755	4,993	10,842	924
1909.....	56	556	8,106	36,744,037	8,631,453	660	4,907	10,410	898
1910.....	89	703	8,292	1,399,400	4,485,600	1,124	5,733	20,390	635
1911.....	66	944	9,446	3,163,554	1,902,798	1,173	6,616	16,489	612
1912.....	43	1,053	6,396	667,350	1,516,911	1,834	10,585	24,944	1,115
1913.....	53	635	10,204	5,855,085	3,626,938	1,499	8,696	24,659	975

Year.	Iron.				Lead.				
	Ore.	Pig and Old.	Manufactures.	Iron and Steel Bars, Sheets, Wire, etc.	Ore.	Pig, Alloys, Crude.	Litharge.	Red and Yellow.	White.
1900.....	233,156	95,530	$4,533,599	10,313	501	7,916	141	354	106
1901.....	218,476	90,287	4,443,670	10,902	1,270	10,722	189	433	135
1902.....	197,525	43,314	4,304,818	11,584	1,879	8,706	149	428	221
1903.....	217,979	47,354	4,508,224	11,025	1,355	9,190	141	423	173
1904.....	182,515	35,091	4,976,342	9,402	1,436	7,917	146	372	138
1905.....	228,149	49,383	5,722,976	33,256	247	7,282	101	349	88
1906(f).....	232,558	57,341	6,153,698	5,085	189	11,732	82	310	75
1907.....	390,322	151,848	(g)29,520	29,268	204	12,547	98	381	126
1908.....	423,940	224,740	(g)45,235	88,396	559	17,116	161	616	201
1909.....	374,088	147,459	(g)48,344	34,025	7,560	20,697	230	599	57
1910.....	307,190	185,604	51,869	44,277	6,354	17,065	411	574	139
1911.....	469,552	112,907	53,590	32,687	1,200	17,238	299	622	108
1912.....	628,867	244,532	64,621	48,137	3,240	16,961	403	448	94
1913.....	942,312	188,324	.....	.....	8,055	12,455	402	367	113

Year.	Magnesium Chloride.	Manganese Ore.	Millstones.	Mineral Paints.	Nickel, Old and Crude.	Nickel and Cobalt Ores	Nitric Acid.	Peat and Peat Coke.
1900.....	2,100	7,016	1,672	4,958	258	406	36	2,664
1901.....	2,529	6,367	1,595	5,109	277	788	22	2,896
1902.....	2,621	15,595	1,410	4,831	265	225	90	3,234
1903.....	3,118	38,529	1,395	4,733	268	385	7	3,097
1904.....	2,997	35,357	1,282	5,563	402	656	24	2,676
1905.....	3,495	30,483	1,467	6,018	632	391	14	2,432
1906(f)...	4,050	33,406	1,176	4,660	773	*Nil.*	12	1,918
1907.....	5,006	70,067	1,469	6,043	1,192	*Nil.*	12	4,460
1908.....	5,011	31,023	1,474	5,909	1,521	114	11	6,459
1909.....	6,095	44,970	1,357	5,773	2,116	*Nil.*	30	5,993
1910.....	6,616	59,951	1,510	7,340	1,606	*Nil.*	37	5,002
1911.....	7,171	78,790	1,494	7,157	1,598	0.1	27	5,115
1912.....	8,344	62,202	2,175	8,468	2,508	1.8	54	6,356
1913.....	7,799	67,278	2,066	6,984	1,895	.....	39	4,264

Year.	Petroleum Products.			Phosphorus and Phosphoric Acid.	Potassium Salts.			Pyrite.
	Crude Oil.	Refined Oil.	Paraffin.		Carbonate.	Chloride.	Chromate.	
1900.....	20,813	22,963	5,080	204	1,029	3,633	11	60,317
1901.....	22,545	18,067	5,294	222	1,442	4,356	21	54,202
1902.....	24,830	15,864	4,238	225	485	3,377	11	60,235
1903.....	19,710	19,382	2,598	237	197	3,727	9	73,835
1904.....	20,110	22,715	1,470	193	222	3,557	3	65,397
1905.....	18,974	24,961	888	222	154	3,864	5	86,338
1906(f).....	13,522	9,693	403	178	602	3,729	(e) 5	87,973
1907.....	18,345	11,441	524	219	174	4,807	(e)38	130,270
1908.....	3,118	9,705	358	234	324	5,009	(e)98	130,793
1909.....	1,357	9,093	508	231	314	4,782	(e)86	141,858
1910.....	18,977	16,868	457	253	185	5,052	69	153,106
1911.....	19,070	19,737	632	233	201	3,666	55	150,974
1912.....	17,874	21,153	546	258	339	5,280	55	186,690
1913.....	19,125	31,590	299	255	157	5,216	175	130,526

Year.	Quicksilver Kg.	Salt.	Sand.	Silver.		Slag and Slag Wool.	Roofing Slate.
				Bullion. Kg.	Specie.		
1900.....	1,300	39,822	77,930	29,300	$199,955	.....	13,047
1901.....	2,600	39,625	83,401	41,800	207,669	.....	11,555
1902.....	1,300	46,128	92,617	177,900	237,104	.....	14,378
1903.....	1,600	48,793	94,492	150,400	250,299	.....	11,531
1904.....	2,500	94,103	97,364	36,700	420,413	.....	9,170
1905.....	2,400	.....	104,195	36,100	143,152	.....	8,852
1906(f).....	1,800	32,182	134,526	43,000	200,754	109,827	6,020
1907.....	1,200	41,660	180,280	88,182	170,228	107,783	7,537
1908.....	2,000	54,525	177,529	96,700	101,265	115,445	7,178
1909.....	2,600	75,397	183,169	150,980	172,201	155,812	6,915
1910.....	2,300	96,936	188,762	161,600	121,000	147,192	9,019
1911.....	2,900	99,921	225,743	195,000	70,102	147,179	8,060
1912.....	3,700	113,287	249,766	91,110	78,361	204,946	7,824
1913.....	4,400	110,923	235,775	148,580	206,032	214,726	6,351

Year.	Sodium Salts.						Sulphur.
	Bi-sulphate.	Carbonate.	Carbonate (Calcined).	Hydrate.	Nitrate.	Sulphate.	
1900 ..	73	104	1,141	1,836	54,559	5,110	27,795
1901 ..	98	77	911	1,280	63,283	4,452	25,300
1902 ..	17	97	312	1,030	39,958	5,997	23,878
1903 ..	13	110	327	956	54,896	6,116	22,625
1904 ..	103	103	1,109	659	54,887	5,409	30,505
1905 ..	167	168	965	475	66,740	5,258	30,227
1906(f)	86	382	303	218	49,862	7,508	26,755
1907 ..	72	153	283	305	57,023	7,342	34,261
1908 ..	32	124	288	358	69,722	7,596	30,985
1909 ..	26	149	297	832	80,533	9,402	28,639
1910 ..	15	224	354	341	81,781	10,150	34,936
1911 ..	5	297	337	297	65,781	10,842	34,916
1912 ..	10	(i)455	260	302	92,838	14,454	40,913
1913 ..	12	247	262	102	93,025	12,682	39,228

Year.	Sulphuric Acid.	Tin. Ingot, Crude, Old, etc.	Whet-stones.	Zinc.			
				Calamine and Other Ores.	Spelter.	Bars, Sheets, Wires, etc.	White.
1900.....	10,643	3,439	3,643	14,181	17,844	667	875
1901.....	11,712	3,671	3,445	18,403	16,921	579	718
1902.....	12,474	3,638	3,599	20,723	17,034	651	636
1903.....	16,148	3,564	3,774	22,344	17,973	746	698
1904.....	19,878	3,528	4,272	24,039	20,787	731	840
1905.....	17,320	3,845	4,376	22,890	21,874	568	972
1906(f).....	17,020	3,320	4,377	24,014	19,467	595	347
1907.....	20,430	4,433	5,552	24,289	24,092	604	219
1908.....	25,251	4,295	5,916	19,366	26,472	1,010	361
1909.....	27,368	4,587	6,826	24,639	27,148	1,263	349
1910.....	27,421	4,674	6,915	30,880	29,168	1,898	511
1911.....	26,630	4,795	8,066	31,357	33,740	388	471
1912.....	36,714	4,806	6,826	35,376	37,558	1,260	438
1913.....	24,922	4,214	6,579	52,299	31,841	1,264	392

(a) From *Statistik des Auswaertigen Handels des Oesterreichisch-Ungarischen Zollgebiets.* (b) Includes arsenious acid and sulphide. (c) Includes burned asbestos. (d) The values of gold are figured at the rate of one crown = $0.203. (e) Potassium and Sodium. (f) Last 10 months only. (g) Metric tons. (h) Not including 188,884 tons of briquettes. (i) Includes bicarbonate.

MINERAL EXPORTS OF AUSTRIA-HUNGARY (a)
(In metric tons or dollars; 5 crowns = $1)

Year.	Alum.	Aluminium Sulphate and Chloride.	Antimony.		Arsenic, Metallic Oxide, Orpiment, and Realgar.	Asbestos.		Asphalt.	
			Ore.	Regulus.		Crude.	Manufactured.	Rock and Earth.	Mastic and Bitumen.
1900	44	164	247	276	65	47	168	1,218	2,177
1901	55	211	179	385	80	36	165	198	1,909
1902	102	135	174	290	89	65	275	520	301
1903	77	14	128	249	63	89	495	921	483
1904	38	2	200	673	72	290	1,582	403	728
1905	68	34	178	774	42	330	1,397	1,060	457
1906 (f) .	68	80	314	912	66	376	1,708	2,824	799
1907	75	81	92	698	59	351	630	3,787	771
1908	147	92	161	527	51	442	450	1,312	1,030
1909	65	57	97	185	117	264	561	1,800	758
1910	346	85	54	416	9	262	604	1,545	954
1911	157	16	77	267	13	141	992	1,845	1,218
1912	253	7	54	689	2	530	779	1,357	1,920
1913	454	5	.....	.....	.....	243	1,605	326	2,621

Year.	Barium.		Chloride of Lime.	Cement.	Chrome Ore.	Kaolin and Feldspar.	Coal.		Coke.
	Sulphate (b)	Chloride.					Bituminous.	Lignitic.	
1900 ...	23	.....	192	46,761	22	103,178	815,097	7,864,410	262,793
1901 ...	55	4,098	738	44,723	62	97,037	748,802	8,076,575	303,651
1902 ...	64	4,552	426	39,920	51	100,546	691,680	7,888,218	234,911
1903 ...	52	5,091	674	40,239	100	110,181	754,957	8,027,347	280,395
1904 ...	74	4,233	254	43,110	36	127,984	815,570	7,588,555	353,695
1905 ...	26	4,626	978	52,830	46	137,125	903,156	8,035,718	287,790
1906 (f)	2,395	4,503	271	64,883	102	133,326	750,420	7,150,339	246,914
1907 ...	3,119	5,220	308	81,407	161	157,894	849,792	8,876,408	323,243
1908 ...	2,987	2,974	519	65,597	144	154,146	762,867	8,600,683	183,279
1909 ...	2,585	3,737	462	63,463	174	150,878	633,253	8,241,723	198,313
1910 ...	13	4,344	1,213	98,888	140	164,859	615,082	7,492,447	230,735
1911 ...	12	3,741	1,175	168,321	70	174,493	609,737	7,063,981	299,915
1912 ...	2,690	3,658	1,518	149,860	95	187,358	655,106	7,442,392	349,384
1913 ...	753	4,918	2,042	144,596	142	197,693	708,975	7,016,606	369,802

Year.	Fluorspar.	Copper.			Copper Sulphate.	Copperas.	Cryolite.
		Ore.	Crude and Old.	Bars, Sheets, Plates, etc.			
1900.....	45.0	801	471	200	57	748	237
1901.....	6.0	1,042	435	334	23	548	231
1902.....	42.0	1,018	436	381	44	857	363
1903.....	12.0	1,308	1,226	451	45	898	521
1904.....	36.0	574	747	577	50	1,170	574
1905.....	5.0	2,328	1,253	746	49	836	638
1906.....	*Nil.*	341	1,007	816	99	861	*Nil.*
1907 (f).....	*Nil.*	489	624	870	11	1,580	*Nil.*
1908.....	7.0	206	1,126	791	63	2,199	*Nil.*
1909.....	12.0	136	1,250	541	40	1,877	*Nil.*
1910.....	4.0	101	977	700	83	2,273	42
1911.....	0.2	126	1,309	1,109	14	2,124	122
1912.....	13.0	516	1,332	1,642	119	3,090	46
1913.....	15.0	182	1,379	1,297	172	2,653	.....

Year.	Gold.			Graphite.	Gypsum.		Hydrochloric Acid.
	Ore.	Bullion. (c)	Specie. (c)		Crude.	Calcined.	
1900	1	$120,988	$11,582,571	18,995	502	1,723	1,659
1901	0	42,427	6,880,888	14,900	461	1,206	1,632
1902	.....	22,939	13,485,087	16,771	550	1,041	791
1903	3	10,150	11,052,944	17,302	342	1,510	3,530
1904	64	5,278	9,649,605	17,430	392	1,510	3,722
1905	1,059	9,338	10,995,089	18,535	363	1,652	4,085
1906	936	88,264	8,015,967	16,871	1,970	686	2,942
1907(f)	996	1,234,291	13,061,517	21,704	3,841	801	3,708
1908	613	70,005	11,978,828	16,535	7,241	807	3,720
1909	548	3,426,539	19,470,382	18,484	3,675	809	3,263
1910	(h)	1,750,600	10,891,800	21,191	5,110	590	4,856
1911	(h)	6,909,408	15,220,358	21,204	3,689	914	5,834
1912	573	10,952,642	21,008,500	25,246	4,113	1,174	8,461
1913	102	2,092,318	13,719,496	24,492	2,544	988	8,969

Year.	Iron.				Lime.	Magnesium Chloride and Glauber Salts.	Magnesite (Calcined).
	Ore.	Pig and Old.	Manufactures.	Iron and Steel Bars, Sheets, Wire, etc.			
1900	263,421	53,426	40,344	65,019	86,273	7,321	(c)
1901	229,624	26,304	46,508	28,841	82,399	7,960	40,236
1902	241,806	42,592	30,137	45,517	81,634	5,333	53,467
1903	252,520	60,237	40,807	63,031	95,644	2,360	69,058
1904	295,017	66,442	60,252	64,698	101,753	2,151	53,781
1905	373,077	63,780	63,828	69,672	94,751	1,272	92,359
1906(f)	234,924	43,694	73,575	50,247	87,468	4,094	87,765
1907	220,767	37,581	56,472	69,669	89,305	6,905	113,695
1908	220,357	17,494	32,110	29,227	62,938	2,622	87,049
1909	178,464	22,627	25,455	40,837	77,586	5,446	125,666
1910	144,827	96,114	73,473	100,541	391,989	6,332	182,911
1911	114,166	87,975	60,918	75,630	511,996	2,715	147,481
1912	111,436	50,328	48,147	49,907	583,812	2,212	171,196
1913	106,071	21,148	.....	.....	678,194	2,151	200,947

Year.	Lead.						Manganese Ore	Millstones.	Mineral Paints.	Nickel and Cobalt Ores.
	Ore.	Dross.	Litharge.	Metal and Alloys.	Red and Yellow.	White.				
1900	2,628	66	242	393	34	34	463	1,871	1,906	114
1901	4,143	112	179	68	32	23	398	1,971	1,947	120
1902	5,478	154	124	109	25	37	411	1,886	2,136	34
1903	8,961	147	145	152	19	25	724	2,311	1,873	12
1904	7,575	144	167	464	54	52	1,234	2,276	1,840	26
1905	7,944	342	141	957	60	39	995	2,232	2,091	16
1906(f)	4,891	223	302	602	16	52	4,170	1,763	1,367	42
1907	8,360	420	255	197	9	54	5,273	2,422	1,697	29
1908	7,107	488	312	199	22	50	2,109	3,293	2,292	*Nil.*
1909	5,711	294	343	306	125	80	787	3,849	2,577	*Nil.*
1910	6,163	322	160	418	44	510	285	3,970	3,542	13
1911	5,493	154	768	670	24	35	588	3,513	3,426	1
1912	8,618	.....	28	548	19	82	534	3,530	4,272	0.3
1913	2,828	.....	36	1,060	3	32	550	3,083	3,831	4.0

Year.	Nitric Acid.	Ozokerite.	Peat and Peat Coke.	Petroleum. (d)	Benzine.	Paraffin.	Potash.	Potassium Chloride.	Pyrite.	Sulphur.
1900....	519	5,162	5,607	33,032	18,361	26	7,792	879	17,162	1,285
1901....	632	2,717	4,558	19,804	17,021	14	4,234	909	16,491	1,225
1902....	769	2,285	4,927	40,683	13,884	24	3,229	772	9,547	1,136
1903....	908	2,258	3,638	74,454	14,000	1,153	3,409	802	10,857	1,123
1904....	858	2,093	3,980	122,419	13,706	5,992	4,604	445	9,891	988
1905....	1,377	1,614	3,746	200,736	8,187	8,996	5,511	1,048	9,168	859
1906(f)	1,303	2,034	2,517	198,325	13,472	9,996	3,814	1,005	7,208	760
1907....	754	1,813	4,001	212,527	12,638	14,758	5,864	1,280	5,646	784
1908....	882	1,648	4,416	351,262	25,599	28,808	4,697	776	6,286	998
1909....	745	2,321	3,395	470,085	32,532	38,043	5,667	793	4,975	1,295
1910....	1,121	2,585	1,963	271,467	39,452	44,432	5,271	957	4,565	658
1911....	1,047	1,859	2,869	220,499	41,923	38,058	4,801	943	1,190	534
1912....	1,251	2,525	1,421	338,271	68,698	51,694	4,456	855	5,041	1,048
1913....	1,373	2,275	1,155	245,184	49,773	43,102	7,460	1,370	3,885	312

Year.	Sulphuric Acid.	Tin.			Whetstones.	Zinc.				
		Ingot and Alloys.	Bars, Plates, Sheets, etc.	Dross.		Ore.	Metallic and Alloys.	Sheets, etc.	White.	Dross.
1900...	12,693	153	102	208	2,270	20,379	1,088	502	1,719	149
1901...	10,373	162	109	257	2,359	23,150	1,374	813	2,720	167
1902...	9,451	193	128	188	2,852	24,519	2,002	1,127	3,113	237
1903...	8,369	292	111	158	2,569	15,108	4,420	729	3,446	267
1904...	9,101	126	102	123	2,159	17,314	4,606	532	3,666	158
1905...	12,823	197	94	78	2,355	19,602	5,023	498	3,861	113
1906(f)	10,493	221	62	83	1,541	15,933	4,578	323	3,504	4,285
1907...	15,190	333	84	160	1,900	19,516	4,608	585	4,873	4,873
1908...	13,581	257	49	172	2,009	19,233	6,604	880	4,131	4,131
1909...	11,232	558	82	59	1,677	19,970	7,031	867	5,078	5,078
1910...	12,016	509	58	70	2,411	22,397	8,720	303	4,968	(g)
1911...	12,111	759	77	59	1,769	16,744	710	411	4,639	(g)
1912...	16,216	(i)1,038	42	.....	1,414	14,539	(i)10,356	2,483	5,890	.....
1913...	14,902	1,061	32	.....	1,358	16,376	13,174	1,383	5,514	.....

(a) From *Statistik des Auswaertigen Handels des Oesterreichisch-Ungarischen Zollgebiets.* (b) Includes artificial barium sulphate. (c) Previous to 1901, magnesite was included with other minerals not elsewhere specified. (d) From 1895 to 1898, inclusive, includes crude and refined petroleum; from 1899 to 1905, inclusive, lubricating oil is also included. (e) Where gold or silver values are reported. 1 crown = $0.203. (f) Last 10 months only. (g) Not reported. (h) Values in gold, $40,200 and $38,760. (i) Includes dross.

BELGIUM

Figures in full-faced type are either provisional figures or estimates.

MINERAL, METALLURGICAL AND QUARRY PRODUCTION OF BELGIUM (a)

(In metric tons except where otherwise noted)

Year.	Barytes.	Chalk-marl. *Cubic Meters.*	Coal.		Coke.	Flint. *Cubic Meters.*	Iron Ore.
			Bituminous.	Briquets.		For Earthen-ware.	
1906....	22,365	1,521,660	23,569,860	1,887,090	2,712,760	14,900	232,570
1907....	23,000	1,537,210	23,705,190	2,040,670	2,771,920	15,050	316,250
1908....	25,070	1,441,005	23,557,900	2,421,210	2,632,890	15,430	188,780
1909....	31,400	1,445,015	23,517,550	2,707,390	2,972,920	15,280	199,710
1910....	4,900	1,546,750	23,916,560	2,651,190	3,110,820	16,400	122,960
1911....	25,200	1,667,125	23,053,540	2,778,620	3,160,950	10,950	150,500
1912....	32,400	1,745,070	22,972,140	2,690,510	3,175,500	5,930	167,370
1913....	12,000	1,687,085	22,841,590	2,608,640	3,523,000	16,690	150,450
1914....	*Nil.*	1,051,160	16,714,050	1,799,700	2,001,670	5,400	82,360
1915....	*Nil.*	278,975	14,177,500	1,490,100	514,600	*Nil.*	4,720
1916....	*Nil.*	567,240	16,862,870	1,935,820	792,350	350	30,430
1917....	*Nil.*	374,380	14,931,340	981,930	676,040	*Nil.*	17,000
1918....	*Nil.*	245,500	13,891,400	1,140,600	522,210	600	500
1919....	*Nil.*	575,790	18,482,880	2,547,890	756,890	1,575	4,820
1920....	15,240	1,069,660	22,388,770	2,846,370	1,835,400	10,220	17,260

Year.	Iron, Crude.					Iron and Steel.			
	Foundry Pig.	Forge Pig.	Bessemer Pig.	Basic Pig.	Total Pig.	Ingots of Steel.	Merchant Bars.	Beams & Special Bars.	Tires.
1906....	96,090	218,225	177,900	870,860	1,375,775	1,440,860	552,850	346,420	32,070
1907....	92,280	189,190	88,650	1,008,170	1,406,980	1,521,610	594,170	327,930	34,700
1908....	76,290	116,740	78,950	996,870	1,270,050	1,249,620	544,810	241,060	29,000
1909....	91,040	127,080	56,430	1,340,060	1,616,370	1,580,350	628,740	291,260	33,960
1910....	82,410	115,760	55,650	1,596,970	1,852,090	1,892,160	672,730	340,850	31,860
1911....	52,970	102,690	46,240	1,836,720	2,046,280	2,128,170	711,220	380,160	35,450
1912....	94,810	66,940	44,250	2,093,480	2,301,290	2,442,420	609,930	390,340	40,320
1913....	93,830	66,370	32,260	2,291,390	2,484,690	2,466,630	855,550	213,940	34,140
1914....	60,310	28,660	44,390	1,316,450	1,454,400	1,396,300	489,360	131,860	15,150
1915....	26,260	3,150	14,730	19,780	68,150	98,820	76,670	9,555	2,930
1916....	58,805	17,040	17,400	36,540	127,825	99,371	121,765	12,630	2,630
1917....	*Nil.*	*Nil.*	2,460	5,530	7,990	9,530	44,510	4,730	750
1918....	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	10,540	50,720	500	240
1919....	43,670	*Nil.*	22,930	183,970	250,570	321,890	160,500	37,370	5,390
1920....	60,310	980	49,560	1,005,550	1,116,400	1,192,390	539,090	121,550	18,840

Year.	Iron and Steel.				Lead.		Manganese Ore.
	Rails.	Plates.	Sheets.	Total Wrought and Steel.	Ore.	Pig.	
1906	274,920	166,970	84,150	1,522,995	121	23,765	120
1907	314,760	148,690	82,420	1,575,110	210	27,450	2,100
1908	(c)191,370	135,390	93,790	1,296,050	195	35,650	7,130
1909	214,000	170,750	112,160	1,569,560	150	40,306	6,270
1910	347,890	177,110	122,830	1,834,050	162	40,715	*Nil.*
1911	337,520	211,410	130,250	1,945,220	82	44,308	*Nil.*
1912	339,060	251,380	119,390	1,903,270	107	54,940	*Nil.*
1913	341,870	241,200	138,570	2,162,210	132	53,590	*Nil.*
1914	152,750	160,640	81,900	1,238,780	52	45,560	*Nil.*
1915	29,470	16,895	20,970	164,370	121	16,770	500
1916	9,730	26,205	40,490	223,335	91	15,560	3,870
1917	730	10,360	12,660	75,150	35	22,745	2,020
1918	220	940	13,460	67,040	2	20,630	2,610
1919	53,960	52,020	40,270	411,055	*Nil.*	4,225	*Nil.*
1920	128,500	143,800	118,020	1,293,580	*Nil.*	16,040	*Nil.*

Year.	Mineral Paints.	Phosphate of Lime.	Pyrite.	Slate. *Pieces.*	Silver. *Kg.*	Zinc.			
	Ochers.					Ore (Blende).	Ore (Calamine).	Spelter.	Sheets.
1906	250	152,140	908	43,801,000	173,535	3,858	*Nil.*	148,035	44,525
1907	200	181,230	397	40,102,000	178,020	3,485	5	152,370	45,330
1908	.....	198,030	357	41,180,000	228,000	2,099	3	161,940	43,410
1909	700	205,260	214	41,630,000	271,270	1,229	*Nil.*	174,490	44,850
1910	600	202,880	214	36,440,000	264,655	1,434	*Nil.*	181,745	47,970
1911	540	196,780	122	37,620,000	252,720	836	*Nil.*	198,230	48,450
1912	650	203,110	148	29,600,000	279,960	1,167	*Nil.*	205,940	49,120
1913	600	219,420	268	27,390,000	253,940	949	*Nil.*	204,220	51,490
1914	300	105,330	109	16,430,000	141,590	410	*Nil.*	145,925	30,780
1915	*Nil.*	16,350	129	16,480,000	33,650	796	*Nil.*	51,660	21,350
1916	*Nil.*	77,740	212	19,460,000	41,060	602	*Nil.*	22,930	8,045
1917	*Nil.*	138,300	81	2,270,000	10,490	231	*Nil.*	10,290	1,675
1918	*Nil.*	61,700	6	680,000	4,900	17	*Nil.*	9,245	745
1919	*Nil.*	90,970	60	10,211,000	7,082	*Nil.*	*Nil.*	19,860	21,305
1920	200	133,040	*Nil.*	18,860,000	14,760	*Nil.*	*Nil.*	84,260	57,130

(a) From *Statistique des Industries Extractives et Metallurgiques et des Appareils a vapeur en Belgique* and *Annales des Mines de Belgique.* (c) Includes beams.

CANADA

The statistics of mineral production in the Dominion of Canada as reported by the Department of Mines are summarized in the following tables. The statement of imports and exports for 1907 is for the nine months ending March 31, in consequence of a change in the law whereby the fiscal year was changed from June 30:

MINERAL PRODUCTION OF THE DOMINION OF CANADA (a)
(In metric tons or dollars)

Year.	Arsenic.	Asbestos and Asbestic.	Barytes.	Cement. *Barrels.(j)*		Chromite.	Coal.	Cobalt and Oxide.	Coke. (k)
				Natural Rock.	Portland.				
1907....	317	82,117	1,829	5,775	2,368,593	6,527	9,533,442	.....	(b)
1908....	634	82,448	3,911	1,044	2,665,289	7,341	9,857,754	841	784,788
1909....	1,024	79,197	(b)	*Nil*	4,067,709	2,240	9,526,938	(i)	782,016
1910....	1,362	92,800	(b)	*Nil*	4,753,975	276	11,711,000	(i)	818,450
1911....	1,902	115,136	45	*Nil*	5,692,915	143	10,243,528	(i)	848,280
1912....	1,855	123,679	421	*Nil*	7,132,732	(b)	13,168,941	(i)	1,275,829
1913....	1,535	146,169	581	*Nil*	8,658,805	(b)	13,622,070	(i)	1,376,646
1914....	1,576	106,686	555	*Nil*	7,172,480	123	12,336,088	(i)	921,241
1915....	2,174	124,123	499	*Nil*	5,681,032	11,196	12,035,843	229	1,089,335
1916....	1,983	139,844	1,241	*Nil*	5,369,560	24,962	13,139,336	381	1,314,335
1917....	2,663	139,510	3,166	*Nil*	4,768,488	33,317	12,743,220	490	1,117,548
1918....	3,230	143,573	581	*Nil*	3,591,481	19,953	13,587,974	334	1,141,515
1919....	2,896	144,458	*Nil.*	*Nil*	4,995,257	7,749	12,411,600	241	1,052,778
1920....	2,185	171,176	.....	*Nil*	6,651,980	9,526	15,080,928	269	1,185,387

Year.	Copper. (In Ore, etc.)	Corundum.	Feldspar.	Gold. (c)	Graphite.	Grindstones.	Gypsum.	Iron Ore. (d)	Iron, Pig. All kinds.
1907..	26,025	1,716	11,414	$8,264,765	525	4,881	431,286	283,820	590,444
1908..	28,895	988	7,144	9,842,105	227	3,285	309,254	215,986	572,284
1909..	23,811	1,353	11,594	9,382,230	783	3,877	429,218	243,167	(g) 686,886
1910..	25,262	1,696	14,114	10,205,835	1,263	3,604	476,496	235,342	(g) 726,471
1911..	25,250	1,336	16,074	9,781,077	1,151	4,818	458,550	190,823	(g) 832,376
1912..	35,314	1,778	12,461	12,648,794	1,869	4,003	524,892	107,190	(g) 920,636
1913..	34,926	1,068	15,235	16,598,923	1,962	4,389	577,442	196,558	(g) 1,024,424
1914..	34,364	507	16,388	15,925,044	1,494	3,700	463,375	54,816	(g) 710,675
1915..	45,717	238	13,208	18,976,218	2,390	2,341	430,752	81,403	(g) 828,977
1916..	53,139	61	17,680	19,234,976	3,588	3,155	311,092	127,560	(g) 1,060,750
1917..	49,544	171	18,773	15,272,992	(l) 3,866	2,289	305,120	153,545	(g) 1,063,047
1918..	53,872	124	17,039	14,463,689	(l) 3,645	2,787	138,155	107,478	(g) 1,084,642
1919..	34,034	.....	14,464	15,850,423	(l) 1,397	1,872	275,787	5,337	(g) 832,619
1920..	37,809	.....	33,436	15,853,478	2,020	2,104	389,319	7,126	(g) 989,137

Year.	Steel. (h)	Lead. (In ore, etc.)	Magnesite.	Manganese Ore.	Mica.	Mineral Paints. (Ochers)	Molybdenite. (MoS_2 Content)	Natural Gas.
1907.....	641,374	21,570	.....	.....	(d) $333,022	7,115	.....	$748,541
1908.....	534,117	19,593	109	.....	139,871	4,305	.....	1,012,660
1909.....	684,670	20,801	299	.....	147,782	3,573	.....	1,207,029
1910.....	745,963	14,953	293	.....	190,385	4,365	.....	1,346,471
1911.....	800,510	10,617	899	5	128,667	3,285	.....	1,917,673
1912.....	868,808	16,227	1,555	68	143,976	6,945	.....	2,362,700
1913.....	1,060,510	17,089	467	0	194,304	5,432	.....	3,309,381
1914.....	751,743	19,888	325	25	109,061	5,345	2	3,484,727
1915.....	926,157	21,009	13,407	182	91,905	5,668	13	3,706,035
1916.....	1,295,707	18,823	50,261	868	255,239	7,993	71	3,958,029
1917.....	1,583,786	14,776	52,699	143	358,851	8,536	131	5,045,298
1918.....	1,699,880	23,314	35,712	447	271,550	15,710	171	4,350,940
1919.....	934,726	19,880	10,317	*Nil.*	273,305	10,761	38	4,071,572
1920.....	1,126,753	15,416	16,673	.....	(m) 1,951	17,026	.....	4,225,887

Year.	Nickel. (In ore, etc.)	Petroleum, Crude. *Barrels.* (e)	Phosphate. (Apatite.)	Pyrite.	Salt.	Silver. *Kg.* (In ore, etc.)	Soapstone and Talc.
1907.....	9,610	788,872	680	35,494	65,936	390,359	1,391
1908.....	8,685	527,987	1,447	42,934	72,537	687,504	976
1909.....	11,922	420,755	905	58,645	76,237	856,263	3,945
1910.....	16,905	315,895	1,341	48,871	76,286	1,022,350	6,450
1911.....	15,457	291,092	563	74,978	83,065	1,012,586	6,621
1912.....	20,346	243,336	149	73,976	86,248	993,952	7,504
1913.....	22,539	228,080	349	143,882	91,457	990,538	11,115
1914.....	20,652	214,805	866	204,125	97,126	856,741	9,807
1915.....	30,985	215,464	197	259,494	108,773	828,067	10,782
1916.....	37,629	198,123	184	280,553	120,570	791,874	11,888
1917.....	37,344	213,832	135	377,984	126,018	691,148	14,336
1918.....	41,960	304,741	127	373,418	119,503	665,006	16,483
1919.....	20,204	240,466	24	160,109	134,539	498,290	16,912
1920.....	27,731	196,937	.....	158,528	190,703	397,916	.....

(a) From *Annual Report on the Mineral Production of Canada*, Department of Mines; latest year from *Preliminary Report*. (b) Not reported. (c) Gold values are calculated at the rate of $20.67 per oz. (d) Export. (e) One barrel contains 35 imp. gal. (g) From Canadian ore, 149,444 short tons in 1909, 104,906 tons in 1910, 42,186 tons in 1911, 36,355 tons in 1912, 73,508 tons in 1913, 95,744 in 1914, 158,595 tons in 1915, 115,691 tons in 1916, 46,022 tons in 1917, 47,444 tons in 1918, 38,457 tons in 1919 and 68,828 tons in 1920. (h) Steel ingots and castings. (i) 1909, $94,609; 1910, $51,986; 1911, $221,790; $320,244 in 1912; $695,855 in 1913; $678,619 in 1914, for oxides of cobalt and nickel; values received. (j) Bbl. of 350 lb. each, sold or shipped. (k) Including that from foreign coal. (l) Including artificial graphite. (m) Tons, output.

MINERAL IMPORTS OF THE DOMINION OF CANADA (a)

(In metric tons or dollars)

Year. (r)	Aluminium.		Antimony. (c)	Arsenic.	Asbestos. (d)	Asphalt.	Cement.
	Manufactures. (m)	Ingots, Sheets, etc.					
1908.....	$37,197	$131,762	220	228	$191,204	14,113	$865,275
1909.....	30,076	167,019	201	58	181,710	15,979	473,211
1910.....	42,493	424,006	232	12	198,756	19,661	159,040
1911.....	83,638	782,254	257	115	254,331	23,248	(t)494,446
1912.....	119,070	487,490	233	159	349,655	28,291	(t)936,425
1913.....	126,531	403,700	400	259	497,160	47,353	(t)1,955,177
1914.....	151,261	730,012	322	127	474,499	48,564	(t)352,134
1915.....	87,242	672,527	733	8	226,515	38,175	(t)132,492
1916.....	85,574	700,365	595	146	191,886	38,029	45,295
1917.....	197,950	349,455	278	126	394,540	29,246	29,719
1918.....	224,449	318,444	216	199	528,054	18,229	17,417
1919.....	287,387	114,756	239	100	649,694	18,804	26,437
1920.....	436,468	362,296	584	210	734,302	18,621	47,156
1921.....	531,780	566,944	375	161	977,160	27,261	153,513

Year. (r)	Coal.		Coke.	Copper.	Copper Sulphate.	Gold and Silver.
	Anthracite. (f)	Bituminous. (f)		Ingots, Pig, and Scrap.		Coin and Bullion. (g)
1908.....	2,803,681	7,681,464	561,677	1,638	1,161	6,548,661
1909.....	2,775,680	6,526,797	423,013	1,239	963	9,988,442
1910.....	2,860,196	10,382,156	636,888	2,329	859	6,017,589
1911.....	3,144,130	7,785,259	692,292	2,279	772	10,206,210
1912.....	3,736,169	9,526,138	582,331	2,514	930	26,033,881
1913.....	3,844,062	10,034,383	644,207	2,581	1,153	5,527,979
1914.....	3,979,674	12,479,959	643,693	2,511	606	15,235,317
1915.....	3,971,968	8,279,570	460,381	2,053	335	131,993,031
1916.....	4,429,143	9,631,101	693,607	1,689	862	34,260,202
1917.....	4,144,488	11,730,145	686,389	2,308	921	28,081,120
1918.....	4,768,510	14,878,080	880,455	2,441	1,266	12,293,901
1919.....	3 511 710	15,031,419	988,855	1,921	1,146	.....
1920.....	4,618,345	10,480,800	346,193	2,840	1,085	.....
1921.....	4,380,469	13,978,134	499,075	4,424	1,068	.....

Year. (r)	Graphite.		Gypsum.		Iron and Steel.		
	Crude.	Manufactures.	Crude and Ground.	Plaster of Paris.	Pig and Scrap.	Slabs, Blooms Bars, etc. (x)	Ferro-Alloys.
1908	$3,030	$78,380	8,519	6,955	190,994	35,534	16,139
1909	1,408	75,608	9,359	7,712	62,967	43,263	13,571
1910	5,223	95,900	3,618	19,095	159,515	97,036	14,471
1911	4,300	97,057	11,443	19,664	266,269	139,060	15,773
1912	6,163	84,240	2,130	9,313	214,046	80,250	16,578
1913	6,105	89,719	8,800	28,975	306,927	77,176	20,837
1914	3,639	71,340	4,877	15,084	251,730	145,731	26,256
1915	1,464	43,313	3 236	5,769	69,261	50,086	2,534
1916	3,620	48,614	1,658	2,222	55,171	118,589	12,761
1917	3,008	102,960	3,069	3,548	70,482	73,270	12,069
1918	121,485	112,849	159	2,596	90,233	60,147	13,146
1919	21,203	142,698	213	986	118,782	51,468	31,157
1920	4,483	140,663	1,319	1,432	58,309	42,161	1,123
1921	5,615	156,951	4,453	2,931	178,968	.....	8,191

Year. (r)	Kainite.	Lead.				Lime.		Mineral Paints (Ochers).
		Pig and Scrap.	Bars and Sheets.	Litharge.	Pigments and Zinc White.	Burned. *Barrels.*	Chloride.	
1908	743	2,902	782	864	5,743	129,379	3,421	788
1909	562	2,273	623	550	3,998	153,934	2,697	546
1910	687	5,755	580	915	4,433	191,527	4,554	914
1911	339	5,292	707	750	5,312	176,730	4,745	1,169
1912	262	10,934	1,356	745	4,921	230,013	5,584	1,358
1913	19	10,980	918	1,197	6,627	360,242	5,248	1,649
1914	180	5,078	654	512	7,547	.....	6,264	1,605
1915	350	7,539	358	479	5,350	.....	2,446	1,282
1916	44	22,928	477	1,043	6,090	.....	4,973	1,162
1917	174	5,473	450	1,147	7,274	.....	3,670	1,774
1918	355	5,564	429	1,081	7,471	(b)9,980	3,428	1,851
1919	80	4,619	372	835	8,198	(b)4,708	5,505	1,439
1920	755	5,459	283	919	9,531	(b)2,934	10,924	1,379
1921	1,271	10,943	318	983	8,068	(b)2,318	19,922	2,496

Year. (r)	Nickel. (s)	Petroleum Products.		Platinum.	Potassium Salts.		Quicksilver.
		Mineral Oil, etc., Crude or Refined. *Gallons.*	Paraffin Wax and Candles.		Except Saltpeter.	Saltpeter.	
1908	.....	8,844,129	102	$63,582	3,396	2,653	81
1909	$ 67,107	13,095,593	103	47,371	1,570	925	42
1910	98,238	(u)48,384,763	253	80,180	2,497	665	129
1911	137,114	(u)66,119,105	931	136,823	3,152	1,490	59
1912	135,227	88,916,283	808	190,770	3,734	1,049	49
1913	194,079	164,013,894	892	221,300	5,643	835	67
1914	144,343	202,540,731	717	121,336	8,057	776	115
1915	172,037	211,900,141	623	65,008	4,139	1,034	67
1916	239,495	213,670,889	549	100,415	1,706	850	83
1917	402,831	301,773,484	537	83,409	402	277	39
1918	293,611	384,572,804	1,004	98,507	125	425	41
1919	225,463	437,476,494	811	28,010	462	340	15
1920	230,565	417,573,844	662	197,835	3,749	230	24
1921	257,043	452,711,216	675	100,130	8,809	372	82

Year. (r)	Sal-Ammoniac.	Salt.	Silex.	Sodium Salts, Except Chloride.	Sulphur.	Tin and Tin-ware. (o)	Zinc.
1908	172	105,286	1,131	39,154	23,494	$1,619,647	2,521
1909	162	119,660	417	33,787	19,981	2,984,065	2,993
1910	303	121,473	582	47,913	19,484	3,512,615	(v)7,606
1911	346	111,174	468	62,969	22,935	4,235,848	(v)6,069
1912	377	119,114	337	74,016	20,430	3,710,102	7,217
1913	544	100,494	658	98,561	32,984	3,055,943	9,397
1914	356	132,777	755	100,701	27,093	6,350,610	7,402
1915	430	121,683	582	78,894	39,412	4,783,108	7,230
1916	420	125,804	402	96,321	34,411	5,312,847	7,357
1917	351	143,778	1,608	116,764	76,179	10,317,431	7,251
1918	487	160,352	744	127,111	67,443	15,241,179	8,649
1919	314	147,977	54	139,840	88,286	15,131,175	5,745
1920	558	135,287	727	76,977	71,827	11,975,062	3,912
1921	652	136,949	1,030	95,708	107,801	15,335,402	2,095

EXPORTS OF DOMESTIC MINERAL PRODUCE FROM THE DOMINION OF CANADA (a)

(In metric tons or dollars)

Year. (r)	Antimony Ore.	Asbestos.	Chromite.	Coal.	Coke.	Copper. (c)
1908	693	53,543	1,585	1,702,673	50,343	25,824
1909	1	54,188	3,707	1,548,468	70,024	24,642
1910	33	58,083	1,052	1,822,398	44,343	26,107
1911	222	63,348	14	2,100,309	54,380	24,950
1912	1	69,233	.....	1,436,798	13,677	25,595
1913	.....	83,299	.....	1,920,809	56,271	36,717
1914	.....	96,159	.....	1,360,029	66,512	37,772
1915	306	67,968	72	1,372,431	47,978	28,438
1916	970	80,611	10,649	1,788,679	39,737	52,995
1917	609	87,086	11,944	1,722,941	35,290	61,265
1918	604	128,005	15,805	1,725,503	23,599	53,824
1919	51	135,394	14,198	1,657,127	24,468	53,094
1920	*Nil.*	117,212	7,110	1,923,389	16,213	36,668
1921	*Nil.*	174,546	7,481	2,065,878	34,502	33,645

Year. (r)	Gold. Quartz, Dust, etc.	Graphite.	Grindstones.	Gypsum, Crude.	Iron Ore.	Lead. (p)
1908	$8,817,041	167	$28,726	340,235	23,863	12,650
1909	7,392,610	396	18,019	239,139	3,568	5,459
1910	6,110,473	1,164	13,754	304,736	28,608	8,395
1911	5,344,465	362	23,914	325,928	95,080	1,451
1912	7,211,438	1,395	30,513	324,324	34,162	52
1913	11,231,476	1,572	27,375	344,183	123,004	93
1914	13,326,755	1,367	54,584	359,287	103,126	125
1915	15,406,510	451	45,889	292,800	198,412	328
1916	16,870,394	366	19,971	348,923	75,212	1,406
1917	19,671,026	180	36,646	205,575	155,773	7,924
1918	13,688,700	65	29,767	182,320	143,258	7,343
1919	9,202,033	573	48,947	62,628	119,470	11,497
1920	5,974,334	1,459	35,719	149,428	6,790	9,521
1921	3,038,779	1,421	41,728	229,610	16,304	5,040

Year. (r)	Manganese Ore.	Mica.	Nickel. (y)	Petroleum, Crude and Refined. (q)	Pyrites.	Salt. *Bushels.* (w)	Silver (in Ore, Bullion, etc). *Kg.*
1908.....	1	409	8,596	3,389	17,835	35,543	515,161
1909.....	3	243	8,895	q)195	23,087	3,040	733,248
1910.....	5	397	13,891	9,093	24,439	6,088	932,098
1911.....	2	370	15,771	1,493	32,396	6,625	1,049,153
1912.....	12	348	15,073	38,663	25,279	109,963	960,586
1913.....	7	415	21,849	152,746	3,109	60,536	1,096,835
1914.....	.....	321	22,949	25,443	42,006	165	1,143,337
1915.....	82	387	20,604	18,376	87,021	15,865	788,656
1916.....	489	392	31,912	512,443	131,598	9,227	864,527
1917.....	581	608	37,476	238,875	137,038	10,082	741,657
1918.....	143	544	37,671	93,174	254,122	102,173	683,048
1919.....	711	349	35,755	3,324,464	215,534	26,573	614,580
1920.....	550	3,072	20,022	5,358,836	75,872	17,728	385,044
1921.....	578	2,582	21,327	3,327,591	(z)108,053	8,347	413,392

(a) From Tables of the *Monthly Report of the Trade of Canada.* (b) Metric tons. (c) Includes regulus and salts of antimony. (d) Asbestos in any form except crude, and all manufactures of. (e) Includes copper in ore, matte, regulus, etc. (f) Includes coal dust. (g) Coin, gold and silver, except U. S. silver coin. (h) Includes black lead and crucibles (clay or graphite). (i) Includes Canadian lead ore refined in the United States. (m) Unclassified. (n)Includes chromic iron ore. (o) Includes tin plate and cans. (p) Includes lead contained in ore, etc. (q) Gallons. (r) Fiscal year ending March 31. (s) Includes silver-nickel and German silver. (t) Weight, 64,176 tons; 46,821, 247,940, 35,431, and 14,370 net tons. (u) Includes all oils. (v) Not including manufactures. (w) Using 60 lb. per bushel. (x) Does not include rolled, cast, or forged material. (y) Includes nickel in ore, matte, etc. (z) Sulphur content.

CHINA

The official statistics of mineral imports and exports are summarized in the following table:

MINERAL IMPORTS OF CHINA (a)

(In metric tons)

Year.	Brass and Yellow Alloys.	Copper.	Lead.	Nickel.	Kerosene. *Gal.*	Quick-silver.	Tin.	Tin-plate.	Zinc.	
									Spelter.	Sheet, etc.
1912...	970	7,368	6,187	56	197,902,362	49	2,548	21,036	443	861
1913...	1,628	12,144	6,511	109	183,984,052	40	3,566	21,983	529	1,971
1914...	1,646	17,461	7,093	61	225 464,201	21	3,922	25,369	509	851
1915...	802	2,131	5,681	66	185,070,111	11	2,503	24,066	17	61
1916...	693	2,375	5,121	126	**147,390,253**	22	3,137	21,006	40	379
1917...	988	2,532	5,205	45	**157,910,941**	14	2,866	14,450	62	469
1918...	1,159	7,970	5,305	65	110,202,234	7	1,554	19,100	316	331
1919...	1,606	21,621	10,032	425	199,309,753	36	8,771	25,331	1,072	492

MINERAL EXPORTS OF CHINA (a)

(In metric tons)

Year.	Antimony.		Iron.		Lead.		Quick-silver.	Tin.	Zinc.	
	Ore.	Metal.(b)	Ore.	Pig and Mnfd.	Ore.	Pig.			Ore.	Spelter.
1912.....	2,054	13,531	355,538	12,604	4,276	20	4.3	8,786	7,170	760
1913.....	4,351	13,032	274,064	64,811	4,066	42	2.1	8,390	9,550	908
1914.....	4,972	19,645	299,515	60,068	3,722	235	59.7	7,215	7,374	310
1915.....	1,873	23,357	308,973	96,537	57	687	40.7	8,006	8,541	2,328
1916.....	12,958	24,740	311,932	159,475	9,899	1,244	177.7	8,403	452	803
1917.....	4,254	38,539	340,878	163,948	13,953	825	254.0	13,038	251	476
1918.....	480	16,568	378,682	190,514	944	463	292.0	8,820	166	129
1919	580	8,343	640,431	167,681	137	11	80.0	8,832	2	109
1920	1,352	14,282	682,950	198,377	2,391	330	45.5	11,487	9,116	98

(a) From annual reports of the Imperial Chinese Maritime Customs. (b) Regulus and refined.

FRANCE

In the following tables are given the statistics of mineral and metal production in France and the French colony New Caledonia, together with the foreign commerce of France in mineral and metal products. Figures in full-faced type are either provisional figures or estimates.

MINERAL AND METALLURGICAL PRODUCTION OF FRANCE (a)
(In metric tons)

Year.	Alumi-nium.	Antimony.		Arsenic Ore.	Asphal-tum.	Barytes.	Baux-ite.	Bitu-men. (c)	Cement.
		Ore.	Metal.						
1909	6,092	28,105	5,444	2,141	44,800	14,111	130,149	169,000	1,374,574
1910	6,425	28,130	4,640	8,045	38,500	11,632	196,056	169,769	1,521,131
1911	7,400	29,267	4,775	19,000	39,000	10,064	254,831	170,000	1,795,000
1912	10,200	11,018	(b)5,406	81,880	31,535	13,620	258,929	312,000	1,924,277
1913	13,483	17,036	6,390	70,613	30,892	12,236	309,294	324,601	1,930,066
1914	9,962	3,416	1,545	250	22,170	.....	.....	166,125	.....
1915	6,017	6,353	2,834	1,300	10,179	.....	56,522	66,831	.....
1916	9,601	19,037	4,395	1,800	17,559	.....	106,200	98,480	.....
1917	11,064	19,453	4,534	344	12,964	.....	120,916	116,679	.....
1918	12,019	10,020	2,056	728	11,961	.....	.....	104,234	.....
1919	**12,000**	3,255	.....	2,261	11,065	.....	163,447	.....	.....
1920	.....	3,880	.....	523	22,252	.....	186,693	.....	.....

Year.	Coal.	Lignite.	Peat.	Copper.		Gold.	Gypsum.	
				Ore.	Metal.		Crude.	Calcined.
1910	37,634,893	715,000	48,415	222	12,933	$1,706,580	64,181	1,533,298
1911	38,521,000	709,000	58,521	35	13,200	1,463,519	59,648	1,640,698
1912	41,145,000	751,000	43,000	242	11,907	1,993,620	25,900	1,700,000
1913	40,050,888	793,330	44,878	521	11,968	153,009	66,218	.....
1914	26,840,911	687,198	36,716	110	10,053	857,492	.....	.....
1915	18,855,544	677,388	20,096	95	850	143,519	.....	.....
1916	20,541,595	768,478	31,404	1,057	1,250	140,499	.....	.....
1917	27,757,411	1,157,996	52,099	1,377	1,000	101,659	.....	.....
1918	24,941,182	1,317,901	129,044	811	450	h) 2,578	.....	.....
1919	21,567,009	909,757	.....	*Nil.*	.....	(h) 10,224	.....	.....
1920	24,303,228	971,076	.....	373	.....	(h) 4,137	.....	.....

Year.	Iron.				Lead.		Lime.	Manga-nese Ore.	Mill-stones.
	Ore.	Pig.	Wrought Iron.	Wrought Steel.	Ore. (d)	Pig. (e)			
1910.	14,605,542	4,038,000	526,000	2,324,000	14,536	20,226	2,110,540	7,925	32,461
1911.	16,639,000	4,470,100	518,000	3,812,665	14,098	23,635	3,291,000	6,036	34,255
1912.	19,160,000	4,939,194	525,000	4,403,688	13,953	31,086	3,807,596	5,576	33,751
1913.	21,918,000	5,207,307	405,972	4,686,866	17,081	28,817	2,838,392	7,732	29,994
1914.	11,251,753	2,736,384	271,081	2,801,801	13,596	29,601	.....	6,393	.....
1915.	620,254	584,235	155,463	1,110,671	9,327	14,539	.....	10,324	.....
1916.	1,680,684	1,310,756	216,734	1,784,221	22,607	24,276	.....	10,807	.....
1917.	2,034,721	1,408,283	195,857	1,991,040	21,943	21,235	.....	11,589	.....
1918.	1,671,851	1,292,958	193,812	1,800,079	12,728	12,778	.....	9,871	.....
1919.	9,429,789	2,412,149	.....	2,186,260	2,211	11,104	.....	4,815	.....
1920.	13,871,187	3,317,371	.....	2,961,508	4,808	**11,800**	.....	5,697	.....

Year.	Mineral Paints (Ochers)	Nickel.	Phosphate Rock.	Pyrite.	Salt.	Silver. Kg.	Sulphur Ore. (g)	Zinc.	
								Ore.	Metal.
1910....	32,870	2,100	333,506	250,432	1,051,427	52,957	2,641	50,624	52,590
1911....	34,542	1,180	312,204	277,900	1,339,000	47,277	1,200	43,761	57,111
1912....	41,810	1,725	313,151	282,202	1,099,000	63,736	1,000	45,929	62,650
1913....	56,240	1,500	298,859	311,167	1,281,978	31,268	659	46,577	67,896
1914....	.....	3,392	274,300	199,326	849,437	26,403	.....	46,057	42,473
1915....	.....	2,159	.....	196,606	799,902	12,801	388	23,778	19,180
1916....	.....	2,400	25,910	219,371	1,121,442	14,993	700	34,295	20,258
1917....	.....	1,918	.....	280,797	937,593	11,970	740	38,125	22,929
1918....	.....	713	.....	260,310	1,092,581	8,469	4,200	25,087	18,347
1919....	.....	.....	.....	118,703	660,217	.....	.....	9,152	18,000
1920....	.....	.....	.....	132,443	826,556	.....	.....	5,494	20,141

(a) From *Statistique de l'Industrie Minérale.* (b) Not reported. (c) Includes pure bitumen, bituminous schist and sand, and asphaltic limestone. (d) Argentiferous lead ore. (e) Lead produced from native ores only. (g) Sulphur and limestone impregnated with sulphur. (h) Ores, tons. (i) Regulus and oxide.

MINERAL PRODUCTION OF NEW CALEDONIA. (a)

(In metric tons.)

Year.	Chrome Iron Ore.	Cobalt. Ore.	Copper Ore.	Nickel. Ore.	Year.	Chrome Iron Ore.	Cobalt Ore.	Copper Ore.	Nickel Ore.
1905.....	51,374	7,920	*Nil.*	125,289	1912(c)	51,516	*Nil.*	(d)	74,312
1906....	84,211	2,600	207	118,890	1913(c)	63,370	.....	.....	164,406
1907....	57,367	29,800	437	119,000	1914...	71,077	445	.....	172,000
1908....	25,371	2,360	(b) 10	108,000	1915...	22,142	140	.....	141,000
1909....	40,000	548	9,600	86,000	1916(c).	69,682	308	.....	105,000
1910....	40,000	54	8,000	99,000	1917(c).	54,800	96	.....	30,000
1911....	35,000	*Nil.*	1,900	142,000	1918...	55,177	48	.....	90,650

(a) From *Statistique de l'Industrie Minérale.* (c) Exports, *Echo des Mines.* (d) Copper matte worth $101,000. (e) Includes matte.

MINERAL IMPORTS OF FRANCE (a) (k)

(In metric tons or dollars. 5 f. = $1)

Year.	Aluminium.	Bitumen. (f)	Borax.	Bromides.	Cement.	Coal and Coke.	Copper.		Copper.	
							Ore.	Ingot and Mfrs.	Sulphate.	Oxide.
1905....	18	24,606	1,736	31	21,954	13,910,523	14,252	70,101	23,805	57
1906....	31	99,336	189	93	24,974	17,848,284	11,932	64,590	15,358	97
1907....	25	31,700	1,660	37	24,839	18,706,000	12,063	76,282	10,558	80
1908....	27	48,000	4,034	28	31,550	18,563,000	15,300	86,985	18,143	85
1909....	39	54,000	6,249	25	46,664	19,387,000	27,400	86,143	12,160	282
1910....	.....	36,360	8,322	17	51,905	18,145,872	23,362	93,548	11,887	427
1911....	.....	32,207	3,128	12	86,457	19,740,539	24,585	104,724	17,759	151
1912....	.....	39,508	3,277	20	115,286	19,878,477	19,671	112,148	16,800	134
1913....	94	58,215	15,149	9	120,620	22,866,967	9,653	138,510	21,575	96
1914....	57	38,470	9,209	11	69,349	17,637,149	10,717	89,140	24,071	62
1915....	100	25,596	1,245	103	28,375	19,693,599	2,758	126,127	33,868	10
1916....	739	24,381	7,230	72	10,919	20,213,833	1,591	175,009	20,943	12
1917....	1,350	12,343	3,900	6	13,402	17,295,370	4,030	249,138	43,214	63
1918....	7,786	4,859	1,788	0.1	5,427	15,903,509	427	166,781	42,645	6
1919....	4,843	13,258	6,030	8	12,023	20,929,281	1,096	56,942	17,266	35
1920....	1,387	11,005	7,161	78	52,571	28,560,972	2,845	73,756	16,141	35

Year.	Cobalt Ore.	Iron.					Kaolin.	Lead.		
		Ore.	Pig.	Iron and Steel, Mfrs.	Sulphate.	Oxide.		Ore.	Carbonate.	Pig, Scrap, and Mfrs.
1905....	2,420	2,151,954	121,726	150,480	709	1,330	52,603	35,103	2,306	73,938
1906....	808	2,015,550	135,252	342,411	132	1,311	44,772	43,137	2,072	67,651
1907....	1,396	1,999,000	122,102	336,337	115	1,439	53,447	42,342	1,898	53,359
1908....	1,500	1,454,000	156,618	373,624	117	1,408	58,909	40,700	3,100	70,824
1909....	400	1,202,619	154,031	354,428	75	1,270	59,490	38,400	4,398	68,332
1910....	2.6	1,318,520	168,810	378,227	2,243	1,235	62,920	28,950	3,259	64,517
1911....	0.3	1,350,794	194,225	77,000	4,454	1,511	66,500	47,340	3,095	69,791
1912....	.....	1,454,190	36,637	114,100	2,800	1,466	63,783	42,499	2,919	65,449
1913....	.....	.....	49,612	202,754	3,370	1,544	61,255	39,772	4,041	77,790
1914....	.....	1,044,160	57,241	130,993	1,654	904	45,682	21,780	1,900	41,900
1915....	.....	397,348	166,397	1,133,898	1,755	295	14,003	15,991	1,010	51,700
1916....	.....	824,176	612,012	2,897,553	.....	322	29,346	40,750	3,255	63,739
1917....	.....	507,909	657,023	2,894,860	*Nil.*	314	23,590	36,048	2,114	57,846
1918....	.....	118,612	375,941	1,917,902	256	210	39,328	26,389	1,228	51,441
1919....	.....	303,852	95,097	1,322,443	265	631	38,390	12,225	4,702	55,432
1920....	.....	403,856	121,462	857,915	697	1,494	418,586	33,308	4,541	55,984

Year.	Lime, Chloride of.	Manganese Ore.	Nickel.		Petroleum.	Phosphate Rock.	Platinum *Kg.*	Potassium.	
			Ore.	Metal.				Chloride.	Chromate. (h)
1905....	406	140,871	49,698	632	(*g*)512,727	447,738	4,023	21,819	2,619
1906....	593	127,235	44,960	480	(*g*)213,462	533,213	5,708	26,523	3,024
1907....	232	192,448	45,892	979	(*g*)311,000	636,549	4,373	25,151	3,000
1908(*k*)..	70	170,500	42,200	1,281	(*g*)300,000	767,424	3,955	28,416	3,000
1909(*k*)..	141	177,314	12,200	.....	(*g*)300,000	645,178	5,914	27,248	2,583
1910....	333	188,292	28,001	2,074	(*g*)271,500	687,675	7,795	34,974	3,009
1911....	53	235,400	43,014	6,465	(*g*)375,000	740,375	9,392	39,508	2,991
1912....	24	225,379	27,126	5,032	(*g*)360,000	903,490	6,236	45,174	3,178
1913....	.....	258,929	10,292	4,046	.....	934,679	5,066	46,138	3,245
1914....	.....	153,487	28,580	3,174	(*g*)488,555	661,429	2,921	30,352	2,330
1915....	.....	12,591	19,004	3,892	472,696	325,114	360	699	3,473
1916....	3,150	58,658	8,915	1,760	658,589	285,906	576	357	4,131
1917....	1,363	77,356	5,152	1,871	629,188	134,779	478	1,424	4,108
1918....	2,969	58,984	3,289	823	741,931	233,399	41	1,285	2,648
1919....	5,027	104,993	10,350	1,059	.....	502,641	219	1,048	3,668
1920....	3,520	152,568	709	114	.....	827,321	728	1,925	3,932

Year.	Potassium (*Cont'd*).		Pyrite.	Quicksilver.		Ammonia Salts	Salt.	Sodium.	
	Nitrate.	Carbonate.		Ore.	Metal.			Hydrate.	Nitrate.
1905....	1,022	3,542	271,684	.....	228	11,639	45,241	860	242,629
1906....	684	2,206	349,514	.....	242	18,146	38,361	614	244,191
1907....	924	2,708	355,300	.....	216	29,357	30,000	611	246,920
1908(*k*) .	424	2,277	348,300	.....	180	32,651	33,000	550	299,390
1909(*k*) .	1,288	2,382	275,600	.....	191	25,825	30,000	567	258,743
1910....	132	2,579	309,400	.....	146	27,860	49,800	577	345,160
1911....	174	4,452	318,530	.....	196	23,200	47,200	550	317,725
1912....	53	4,017	486,072	.....	213	25,056	39,500	556	354,776
1913....	72	7,374	581,756	.....	198	24,253	32,966	562	322,115
1914....	291	2,898	604,656	.....	167	10,009	38,681	1,922	297,190
1915....	28	1,184	424,806	.....	330	32,827	32,990	13,002	254,008
1916....	2,996	325	792,347	.....	568	.....	60,578	14,364	540,701
1917....	2,641	465	491,620	.....	490	.....	23,213	19,949	453,665
1918....	2,183	119	321,281	.....	852	.....	20,927	5,169	256,527
1919....	2,789	838	95,363	.....	187	.....	44,924	1,541	166,686
1920....	1,521	2,656	241,184	.....	210	.....	43,781	3,603	261,639

Year.	Sulphur.	Sulphuric Acid.	Superphosphate of Lime.	Tin.		Zinc.	
				Ore.	Metal.	Ore.	Metal.
1905	129,877	10,915	31,729	1,362	9,898	105,069	29,163
1906	131,678	5,268	44,502	1,038	7,687	106,307	26,960
1907	106,050	11,027	29,154	961	7,693	114,699	33,503
1908(*k*)	195,000	10,082	42,878	1,000	8,482	137,900	40,312
1909(*k*)	196,300	11,845	65,560	1,900	9,683	120,600	32,749
1910	202,263	14,642	132,530	1,651	8,517	193,360	19,237
1911	267,969	15,150	79,385	2,544	8,456	160,180	42,785
1912	172,181	13,169	89,059	1,726	8,503	158,429	43,795
1913	186,344	11,001	100,882	2,542	8,722	178,719	39,997
1914	116,018	6,180	231,265	2,132	7,216	99,124	30,361
1915	102,757	25,741	43,144	220	8,914	49,398	36,825
1916	128,095	70,374	16,172	445	10,548	56,727	63,206
1917	78,187	55,739	1,884	333	12,744	36,430	72,909
1918	71,592	1,020	6,170	50	10,165	61,287	45,579
1919	139,990	1,725	12,956	1,371	9,696	40,551	46,762
1920	237,966	7,658	.....	740	6,803	39,667	55,202

MINERAL AND METALLURGICAL EXPORTS OF FRANCE (*a*) (*k*)

(In metric tons)

Year.	Aluminium.	Antimony.		Arsenic Ore.	Cement.	Coal and Coke.	Copper.		Gold. Kg.(*d*)
		Ore.	Metal.				Ore. (*c*)	Metal.	
1903	666	904	1,358	.....	233,835	2,238,735	12,487	11,403	3,139
1904	664	1,191	720	.....	260,686	2,384,928	14,258	12,663	1,537
1905	928	981	815	.....	275,503	(*i*)3,348,010	13,260	13,800	5,740
1906	1,522	3,541	871	.....	329,879	(*i*)1,448,000	8,056	6,130	11,727
1907	1,118	3,460	1,270	13,466	366,624	(*i*)1,224,000	4,151	18,630	6,289
1908	1,332	3,300	2,129	8,600	342,131	(*i*)1,117,000	3,600	17,845	4,455
1909	4,425	4,000	2,408	3,267	316,486	(*i*)1,493,308	6,200	18,775	5,366
1910	4,148	4,583	2,163	2,411	315,020	(*i*)1,580,077	4,163	20,884	7,264
1911	4,058	3,991	1,945	832	333,043	(*i*)1,635,000	8,335	22,690	.....
1912	6,605	1,673	2,890	1,497	361,425	(*i*)2,320,349	6,374	42,307	775
1913	4,514	608	1,808	1,351	398,240	1,304,377	10,154	29,456	394
1914	3,350	128	1,601	1,346	247,444	913,432	5,865	18,546	311
1915	2,946	8	985	.....	130,387	239,905	9,741	4,667	780
1916	2,161	2	2,963	.....	117,711	226,917	755	7,984	683
1917	1,230	1	1,524	.....	64,492	274,214	220	6,692	878
1918	533	1	959	1	33,185	1,955,132	393	4,728	1,050
1919	2,631	154	620	1	73,331	589,830	1,658	7,936	850
1920	2,911	913	1,182	.....	145,325	428,840	1,650	30,315	1,186

Year.	Iron.				Lead.		Manganese Ore.
	Ore.	Pig.	Bars.	Steel.	Ore.	Metal.	
1903	714,173	196,444	40,533	215,737	2,313	13,048	717
1904	1,219,149	191,819	40,374	246,738	1,860	13,467	1,392
1905	1,355,932	218,227	67,240	343,612	3,064	12,903	662
1906	1,759,443	143,142	58,826	236,617	1,354	997	4,103
1907	2,147,000	249,708	84,557	291,434	1,210	1,912	5,167
1908	2,384,000	171,797	86,691	360,509	6,700	1,974	1,000
1909	3,907,338	161,058	96,999	318,925	2,800	2,458	1,149
1910	4,892,542	110,086	122,543	(*k*)302,168	5,855	3,004	722
1911	6,160,100	104,350	171,000	100,000	9,691	2,660	902
1912	8,318,312	216,895	67,000	(*j*)200,085	12,276	1,660	2,282
1913	10,066,628	99,730	.....	(*j*)418,425	14,263	983	1,705
1914	4,828,592	42,755	.....	(*j*)248,130	8,220	816	411
1915	94,864	1,615	.....	(*j*) 9,477	48	581	40
1916	74,561	11,303	.....	(*j*) 26,910	813	6,856	275
1917	126,533	17,433	.....	(*j*) 39,960	405	736	109
1918	68,346	6,999	.....	(*j*) 21,370	122	265	33
1919	1,997,171	129,544	.....	(*j*)216,195	366	1,176	1,309
1920	4,407,486	296,903	.....	(*j*)950,336	2,506	6,431	875

Year.	Nickel, Refined.	Phosphate Rock.	Plaster.	Pyrite.	Silver. *Kg.* (*e*)	Tin (Metal).	Zinc.	
							Ore.	Spelter, Sheets and Scrap.
1904.....	906	78,612	139,551	40,833	23,105	2,300	57,780	19,063
1905.....	1,583	55,240	124,561	21,257	66,904	2,611	72,512	17,802
1906.....	1,088	81,660	142,339	26,216	87,952	601	67,258	19,607
1907.....	1,414	100,508	137,356	24,417	58,199	729	54,316	21,928
1908.....	1,230	71,509	132,924	40,300	56,957	810	57,800	20,589
1909.....	1,940	47,611	120,701	40,200	56,549	886	60,000	24,729
1910.....	2,050	44,384	152,390	56,735	58,294	1,224	56,800	22,975
1911.....	880	31,413	148,952	68,919	17,256	1,520	51,737	25,500
1912.....	1,192	22,062	174,486	43,905	3,856	1,450	60,007	34,124
1913.....	740	21,128	.....	.....	23,524	1,422	58,203	29,733
1914.....	1,103	11,219	.....	.....	35,015	936	21,279	13,549
1915.....	30	1,796	.....	.....	6,298	807	5,600	4,663
1916.....	246	1,727	.....	16,678	2,774	1,374	1,820	4,087
1917.....	36	627	.....	6,993	2,040	403	538	4,164
1919.....	3	36	.....	11,529	2,316	173	439	3,117
1919.....	49	1,517	.....	9,664	12,736	1,178	111	4,930
1920.....	160	3,280	.....	6,678	10,062	1,829	12,038	8,220

(*a*) From *L'Economiste Francais* (representing the *Commerce Spécial*), except for 1903-06, inclusive, which are from *Tableau Général du Commerce et de la Navigation*. (*b*) Not reported. (*c*) Includes matte. (*d*) Gold and platinum in sheets, leaves, threads or jewelry, and crude platinum. (*e*) Silver in sheets, leaves, wire, and jewelry. (*f*) Includes bitumen, bituminous schist and sand, and asphaltic limestone. (*g*) Crude and refined. Transposition from hectoliters to tons was performed by assuming specific gravity of petroleum to be 0.9. (*h*) Includes chromate of soda. (*i*) Includes coke. (*j*) Iron and steel other than pig iron. (*k*) From *Statistique de l'Industrie Minérale* in the years 1908, 1909, 1910. Steel in 1910 not classified as before. 1911 and 1914–1918, from *l'Echo des Mines et Metallurgie*. (*l*) Includes bars and steel.

GERMANY

The mineral production and foreign commerce of the German Empire are given in the following tables in metric tons unless otherwise specified, or in dollars, on the basis of four marks to the dollar. Figures in full-faced type are either provisional figures or estimates.

MINERAL PRODUCTION OF GERMANY (a)

Year.	Alum.	Aluminium Sulphate	Arsenic.		Asphaltum.	Boracite.	Cadmium. Kg.	Coal.	
			Ore.	Salts.				Bituminous.	Lignitic.
1904	3,850	55,881	4,390	2,829	91,736	135	25,245	120,815,503	48,635,080
1905	4,127	52,892	4,913	2,535	103,006	183	24,568	121,298,607	52,512,062
1906	4,494	55,969	6,249	3,052	117,413	161	21,486	137,117,926	56,419,567
1907	4,200	59,473	4,878	2,904	126,649	114	32,949	143,185,691	62,546,671
1908	3,802	53,958	6,065	2,822	89,009	128	32,995	147,671,149	67,615,200
1909	4,179	56,096	6,150	2,911	77,537	149	37,187	148,788,050	68,657,606
1910	4,406	58,349	6,151	3,066	81,208	167	41,100	152,827,777	69,473,883
1911	3,076	.....	4,859	2,981	81,902	160	42,000	160,747,580	73,760,867
1912	.....	.....	4,869	.....	96,117	224	43,000	174,875,297	80,934,797
1913	.....	.....	5,700	.....	105,500	203	.....	190,109,400	87,233,100
1914	.....	.....	4,700	.....	81,800	.....	.....	161,384,700	83,693,600
1915	.....	.....	4,100	.....	32,400	.....	.....	146,867,600	87,948,400
1916	.....	.....	3,600	.....	31,500	.....	.....	159,169,700	94,180,500
1917	.....	.....	5,600	.....	12,300	136	.....	167,747,200	95,542,900

Year.	Cobalt, Nickel, and Bismuth Ores.	Copper.				Gold.	Graphite.
		Ore.	Matte. (b)	Ingots.	Sulphate.		
1904	14,016	798,214	641	30,264	6,584	$ 1,819,538	3,784
1905	10,848	793,488	1,635	31,713	6,988	2,611,812	4,921
1906	.....	768,523	771	32,275	6,757	2,931,750	4,055
1907	2,809	771,227	527	31,946	5,284	3,111,379	4,033
1908	8,535	727,384	328	30,001	7,117	3,162,544	4,844
1909	10,388	798,618	2,242	31,126	6,211	3,366,986	6,774
1910	10,313	925,957	3,735	34,926	5,210	3,227,250	7,415
1911	.....	868,600	1,142	37,452	7,353	3,302,300	11,298
1912	12,861	969,330	2,574	49,447	5,955	**3,322,700**	12,532
1913	.....	886,000	4,100	49,400	6,000	25,717,698	12,100
1914	.....	832,500	4,800	46,200	4,500	15,217,966	13,600
1915	.....	968,000	3,500	58,900	2,900	4,120,148	16,900
1916	.....	1,217,100	3,000	79,800	5,500	7,906,573	30,600
1917	.....	1,132,700	5,000	74,000	6,200	7,400,159	37,500

Year.	Iron and Steel.				Lead.		
	Iron Ore.	Pig Iron. (c)	Wrought Iron and Steel.	Sulphate. (d)	Ore.	Pig.	Litharge.
1904	22,047,393	10,058,273	9,239,302	13,585	164,440	137,580	4,332
1905	23,444,073	10,875,061	10,309,690	12,949	152,725	152,590	3,786
1906	26,734,570	12,292,819	11,307,807	13,376	140,914	150,741	4,137
1907	27,697,127	12,575,159	12,063,632	14,033	147,272	142,271	4,325
1908	24,278,151	11,805,321	10,930,933	15,738	156,861	164,079	5,339
1909	25,505,409	12,917,653	11,719,239	21,838	159,852	167,920	3,059
1910	28,709,700	14,502,183	12,988,177	18,677	148,497	159,851	3,581
1911	29,879,361	15,280,527	14,384,271	17,002	140,154	161,287	3,687
1912	27,199,944	15,220,881	16,508,987	.....	142,839	192,618	4,135
1913	28,607,900	16,763,800	20,419,300	.....	144,900	205,400	.....
1914	20,505,300	12,581,200	16,346,800	.....	129,000	198,400	2,600
1915	17,709,600	10,154,700	14,230,100	.....	119,600	134,700	800
1916	21,333,700	11,342,100	.....	.....	137,200	120,400	400
1917	22,464,800	11,707,100	.....	.....	124,600	98,200	100

Year.	Magnesium Salts.		Manganese Ore.	Petroleum.	Potassium Salts.				
	Chloride.	Sulphate.			Chloride.	Kainite. (f)	Sulphate.	Potassium-Magnesium Sulphate.	Other than Kainite.
1904	25,730	39,412	52,886	89,620	297,238	1,905,893	43,959	29,285	2,179,471
1905	29,017	58,568	51,463	78,869	373,177	2,387,643	47,994	34,222	2,655,845
1906	38,468	43,041	52,485	81,350	403,387	2,720,594	54,490	35,211	2,821,073
1907	32,891	41,105	73,105	106,379	473,138	2,624,412	60,292	33,368	3,124,955
1908	29,775	42,977	67,692	141,900	511,258	2,715,487	55,756	33,149	3,383,535
1909	31,526	53,812	77,177	143,244	624,994	3,181,349	68,539	38,722	3,969,554
1910	32,207	57,314	80,560	145,168	741,259	4,249,667	84,583	37,438	4,062,004
1911	36,764	55,179	87,297	142,992	838,420	4,425,497	107,631	42,253	5,181,379
1912	85,387	99,442	185	134,986	506,744	5,889,238	123,407	54,435	.....
1913	.....	.....	.....	121,000	495,625	.....	121,529	62,945	.....
1914	.....	.....	.....	110,300	.....	.....	.....	.....	.....
1915	.....	.....	.....	99,300	.....	.....	.....	.....	.....
1916	.....	.....	.....	92,700	.....	.....	.....	.....	.....
1917	.....	.....	.....	90,600	.....	.....	.....	.....	.....

Year.	Pyrite.	Salt.		Silver and Gold Ore.	Silver. *Kg.*	Sodium Sulphate.	Sulphur.	Sulphuric Acid.
		Rock.	Evaporated.					
1904	174,782	1,079,868	621,064	10,405	389,827	75,171	209	963,384
1905	185,368	1,165,495	612,062	10,286	399,775	68,454	205	1,228,211
1906	196,971	1,235,041	635,171	8,066	393,442	81,175	178	1,335,128
1907	196,351	1,285,137	665,547	8,280	386,933	80,347	176	1,402,398
1908	219,456	1,331,984	665,651	7,653	407,185	72,667	811	1,391,653
1909	198,688	1,370,668	647,939	7,510	400,562	71,813	1,185	1,434,709
1910	215,708	1,424,064	669,120	6,646	420,003	84,787	1,272	1,616,336
1911	217,459	1,436,492	645,991	4,890	439,580	82,664	1,251	1,534,455
1912	242,121	1,352,524	671,622	595	.....	.....	.....	1,649,681
1913	268,600	675,900	.....	*Nil.*	765,800	.....	.....	1,727,400
1914	232,300	643,400	.....	*Nil.*	651,100	.....	.....	1,505,700
1915	441,600	581,800	.....	*Nil.*	349,400	.....	.....	1,137,900
1916	635,700	596,300	.....	.....	319,000	.....	.....	1,019,000
1917	803,700	511,300	.....	.....	276,100	.....	.....	1,104,300

Year.	Tin.			Uranium and Tungsten Ores.	Zinc.		
	Ore.	Block.	Chloride.		Ore.	Spelter.	Sulphate.
1904	99	4,216	816	23	715,732	193,058	6,185
1905	123	5,233	811	26	731,271	198,208	5,896
1906	.....	6,597	987	.....	704,590	205,691	6,092
1907	.....	5,838	1,812	3	698,425	208,195	5,145
1908	111	6,374	2,266	42	706,441	216,490	5,310
1909	124	8,994	3,247	98	723,565	219,766	5,574
1910	125	11,395	3,391	95	718,316	221,395	6,308
1911	.....	12,412	3,749	.....	699,970	235,776	6,703
1912	(i)	10,646	3,094	70	643,598	269,161	6,413
1913	.....	12,000	.....	.....	646,300	278,800	.....
1914	.....	9,800	.....	.....	533,200	236,000	.....
1915	.....	1,100	.....	.....	488,500	185,300	.....
1916	.....	1,000	.....	.....	527,000	178,100	.....
1917	.....	1,800	.....	.....	527,100	186,800	.....

(*a*) From the *Vierteljahrshefte zur Statistik des Deutschen Reichs.* Where gold is reported, 1 mark = $0.238. (*b*) Includes black copper. (*c*) Includes ferromanganese and spiegeleisen. (*d*) Contains a small quantity of copper and iron sulphate mixed. (*f*) Compound of potassium chloride and magnesium sulphate. (*i*) Included with cobalt, nickel and bismuth.

MINERAL PRODUCTION OF BADEN (a)
(In metric tons or dollars; 4 marks = $1)

Year.	Aluminium Sulphate.	Barytes.	Coal.	Gypsum.	Manufactures of Iron.		
					Cast, Foundry.	Steel.	Wrought.
1899....	2,153	2,430	4,700	29,419	53,608	3,830	1,402
1900....	2,286	2,970	4,930	26,381	50,102	3,532	1,364
1901....	2,260	3,991	3,650	28,183	40,100	8,739	1,158
1902....	2,374	6,234	2,078	33,150	40,973	12,663	1,052
1903....	2,498	8,857	1,990	29,423	45,233	7,666	863
1904....	2,392	9,078	1,485	26,984	64,320	7,687	783
1905....	2,581	11,094	668	28,823	74,128	8,053	842
1906....	2,583	11,984	1,000	25,643	81,387	11,068	466
1907....	2,644	9,303	2,075	29,153	98,430	10,818	533
1908....	2,524	(c) 8,554	2,473	35,217	83,724	10,430	602
1909....	2,329	(c) 15,186	2,356	36,621	83,458	11,643	484
1910....	2,141	(c) 13,832	1,650	41,078	95,795	12,134	239
1911....	2,554	15,014	(b)	42,408	107,784	11,909	244
1912....	.....	15,871	.....	51,778	.....	.....	.....
1913....	.....	16,445	.....	49,767	.....	.....	.....

Year.	Lead Ores.	Salt.	Sulphuric Acid.	Tripoli.	Zinc Ore.
1899.....	(b)	31,197	13,660	12	357
1900.....	67	32,699	15,938	9	3,004
1901.....	369	32,835	17,081	8	2,870
1902.....	450	32,192	19,265	11	2,958
1903.....	350	32,383	19,755	11	3,171
1904.....	265	32,148	35,517	12	5,063
1905.....	264	31,393	40,781	12	4,046
1906.....	246	31,288	38,655	15	1,466
1907.....	278	32,078	42,831	25	2,198
1908.....	329	33,993	41,455	13	2,793
1909.....	372	34,040	42,219	14	3,253
1910.....	419	32,729	56,069	7	3,345
1911.....	191	32,118	47,796	14	3,067
1912.....	428	32,326	.....	14	3,730
1913.....	480	33,502	.....	13	3,882

(a) From the *Uebersicht der Production des Bergwerks-, Hütten-, und Salinen-Betriebes in dem Badschen Staate.* (b) Not reported. (c) Includes fluorspar.

MINERAL PRODUCTION OF BAVARIA (a)
(In metric tons; 4 marks = $1)

Year.	Barytes.	Kaolin.	Coal.	Coal (Lignite).	Copperas and Other Sulphate.	Emery.	Feldspar.	Fluor-spar.	Graphite.
1899..	6,214	25,822	1,004,421	35,736	900	399	287	3,631	5,196
1900..	10,515	58,795	1,185,296	39,165	916	414	460	7,456	9,248
1901..	8,711	35,450	1,203,792	25,224	590	366	788	5,220	4,435
1902..	8,034	92,073	1,233,568	27,337	691	225	447	5,460	5,023
1903..	8,642	88,140	1,356,556	25,189	814	220	1,060	3,410	3,719
1904..	9,411	95,160	1,341,925	53,517	893	265	1,866	4,770	3,784
1905..	10,030	99,910	1,317,951	154,128	844	255	1,710	4,413	4,921
1906..	19,817	98,138	1,381,175	140,290	836	320	1,740	5,570	4,055
1907..	21,500	115,387	1,495,895	286,256	850	326	2,125	4,780	4,033
1908..	17,195	68,551	647,639	1,209,110	910	245	5,859	5,480	4,844
1909..	17,920	187,312	694,191	1,242,088	1,094	305	3,151	5,580	6,774
1910..	24,711	107,660	713,994	1,299,970	1,333	270	2,620	5,132	7,415
1911..	26,234	70,512	763,172	1,548,465	.....	210	3,165	4,680	11,298
1912..	27,199	72,517	790,680	1,704,654	.....	260	6,666	4,220	12,532
1913..	.....	.....	811,000	1,895,000	.....	.....	.....	.....	.....

Year.	Gypsum.	Iron.						Lithographic Limestone.
		Ore.	Bar.	Cast, 1st Fusion.	Cast, 2d Fusion.	Pig.	Steel.	
1899....	29,727	181,981	61,415	(b)	92,459	83,821	134,007	11,962
1900....	35,484	178,441	49,727	29	89,692	82,327	135,411	16,030
1901....	3,581	158,820	29,978	76	76,191	72,071	109,464	9,500
1902....	31,701	157,375	38,429	56	81,874	83,123	115,354	.....
1903....	30,894	162,500	36,853	41	89,804	90,168	127,141	9,890
1904....	22,766	180,342	37,780	40	108,025	92,200	125,483	13,836
1905....	46,247	182,389	36,459	24	112,875	94,242	134,755	11,360
1906....	50,763	203,596	38,508	.....	122,115	97,812	150,129	.....
1907....	48,975	277,280	36,883	*Nil.*	138,659	98,143	150,148	11,590
1908....	51,314	278,681	30,740	*Nil.*	128,234	131,404	176,085	9,858
1909....	51,630	279,514	33,448	*Nil.*	130,129	134,133	219,606	9,420
1910....	54,397	303,844	30,881	*Nil.*	148,261	133,679	249,198	9,790
1911....	60,390	375,409	165,683	*Nil.*	171,976	.....	339,401	8,175
1912....	57,114	450,074	(c)	.....	396,656	195,606	998,624	9,903

Year.	Marl. (For Cement)	Mineral Paint and Chalk.	Pyrites.	Rock Salt.	Soapstone.	Sodium Sulphate.	Sulphuric Acid.
1899....	220,716	9,287	2,516	802	2,197	1,570	123,273
1900....	180,032	11,507	2,120	1,298	1,977	1,821	123,910
1901....	76,663	84,929	2,649	1,319	2,291	1,893	115,775
1902....	178,301	13,947	2,635	832	.....	.....	.....
1903....	200,407	19,486	2,324	879	1,866	.....	.....
1904....	170,698	19,107	3,427	1,139	1,709	.....	.....
1905....	231,310	18,285	3,301	911	1,872	.....	.....
1906....	230,271	22,304	3,918	1,053	.....	.....	.....
1907....	230,583	21,219	5,085	1,393	1,999	1,439	161,868
1908....	307,820	21,310	4,037	1,285	2,199	1,743	149,079
1909....	276,974	21,692	2,952	1,860	2,329	1,265	178,371
1910....	273,727	22,357	4,466	1,192	3,083	1,416	171,131
1911....	265,899	24,258	6,316	782	3,431	2,061	170,039
1912....	341,068	30,033	6,531	1,162	3,221	.....	254,708

(a) From the *Uebersicht der Production des Bergwerks-, Hütten-, und Salinen-Betriebes in dem Bayerischen Staate.* (b) Not reported. (c) With cast iron.

MINERAL PRODUCTION OF PRUSSIA (a)

(Metric tons; 4 marks = $1)

Year.	Alum Shale.	Antimony and Alloys.	Arsenic Products.	Arsenic Ore.	Asphalt.	Boracite.	Cadmium. *Kg.*	Coal.
1903....	580	3,224	1,583	3,538	23,518	135	16,565	108,809,384
1904....	106	2,774	1,573	3,527	26,348	115	25,245	112,755,621
1905....	97	2,795	1,493	4,022	28,872	151	24,568	113,000,657
1906....	634	2,953	1,551	5,430	32,270	124	21,486	128,295,948
1907....	154	3,515	1,591	4,224	39,243	90	32,949	134,044,080
1908....	80	3,596	1,646	5,015	27,444	105	32,995	139,002,378
1909....	60	3,841	1,849	5,731	19,509	123	37,187	139,906,194
1910....	46	4,969	2,068	5,789	21,595	138	41,058	143,771,612
1911....	63	5,411	1,862	4,476	19,956	147	42,575	151,324,030
1912....	104	.....	.....	4,870	21,241	186	.....	165,302,784
1913....	180	.....	.....	5,008	17,795	160	.....	179,861,015
.....	.....	.....	.....	.....	.....	.....	.....	.....
1918....	.....	.....	.....	10,558	.....	.....	.....	152,809,966
1919....	.....	.....	.....	5,117	.....	.....	.....	112,028,796

Year.	Coal (Lignite).	Cobalt Ore.	Cobalt Products.	Copper.	Copper and Iron Sulphate.	Copper Ore.	Copper Matte.
1903....	38,462,766	65	87	28,386	110	761,188	488
1904....	41,153,576	41	85	27,450	95	782,049	601
1905....	44,148,751	22	99	28,874	102	769,381	1,052
1906....	47,912,721	7	98	29,166	94	755,812	525
1907....	52,560,597	*Nil.*	109	28,945	64	755,203	499
1908....	55,456,860	*Nil.*	100	27,301	50	711,921	296
1909....	56,029,554	*Nil.*	93	28,523	55	798,448	1,935
1910....	56,644,291	*Nil.*	94	30,244	44	914,519	2,060
1911....	60,531,943	*Nil.*	107	30,986	27	919,827	996
1912....	65,803,959	*Nil.*	.....	.....	.....	967,785	.....
1913....	70,051,871	*Nil.*	.....	.....	.....	941,402	.....
.....	.....	.....	.....	.....	.....	.....	.....
1918....	83,372,828	.....	.....	.....	.....	1,004,050	.....
1919....	75,953,982	.....	.....	.....	.....	615,808	.....

Year.	Copper Sulphate.	Epsom Salt.	Gold. *Kg.*	Iron.	Iron Ore.	Iron Sulphate.	Lead.
1903.....	2,254	421	949.5	6,614,768	3,786,743	11,086	133,405
1904.....	3,364	289	1,081.9	6,573,507	3,757,651	12,524	128,294
1905.....	3,065	338	1,034.9	7,106,975	4,130,210	12,075	143,270
1906.....	2,724	144	750.2	8,154,880	4,713,928	12,473	140,690
1907.....	2,129	263	771.0	8,266,300	5,077,773	13,014	132,366
1908.....	3,116	398	786.6	7,989,260	4,311,593	14,062	153,541
1909.....	2,500	395	588.2	8,410,824	4,389,950	18,295	156,533
1910.....	1,749	162	566.3	9,995,012	4,823,606	16,119	146,993
1911.....	2,464	114	520.	10,477,263	4,948,711	15,468	147,538
1912.....	.....	.....	.....	.....	5,331,240	.....	.....
1913.....	.....	.....	.....	.....	5,461,670	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....
1918.....	.....	.....	.....	.....	6,203,399	.....	.....
1919.....	.....	.....	.....	.....	4,625,905	.....	.....

Year.	Lead Ore.	Litharge.	Manganese Ore.	Nickel.	Nickel Ore.	Nickel Sulphate.	Ocher and Mineral Paints.
1903.....	151,746	2,710	47,110	1,945	14,058	173	2,850
1904.....	150,328	2,517	52,092	2,333	13,518	207	3,200
1905.....	138,928	2,272	51,048	2,631	10,432	220	3,170
1906.....	127,322	2,744	51,881	2,648	7,472	187	3,635
1907.....	133,528	2,959	72,442	2,093	7,557	189	3,707
1908.....	141,316	4,190	67,241	2,622	8,238	181	3,183
1909.....	158,811	2,365	76,741	3,186	10,095	163	3,435
1910.....	146,830	3,076	80,325	3,497	10,053	213	142
1911.....	135,366	3,441	86,902	3,744	9,609	244	.....
1912.....	140,158	.....	92,474	.....	12,091	.....	.....
1913.....	143,799	.....	(*b*)	.....	13,565	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....
1918.....	123,548	.....	1,034	.....	93,555	.....	.....
1919.....	99,230	.....	553	.....	29,151	.....	.....

Year.	Petroleum.	Potassium Salts.		Pyrite.	Quicksilver. *Kg.*	Salt.	
		Kainite.	All Other.			Common.	Rock.
1903.....	41,733	1,118,270	1,344,038	159,234	2,145	317,475	409,199
1904.....	67,604	1,261,930	1,447,323	163,209	3,030	328,933	394,910
1905.....	57,741	1,580,530	1,734,033	174,641	2,597	328,051	436,942
1906.....	59,196	1,923,088	1,937,181	186,849	5,084	339,675	492,339
1907.....	80,255	1,839,409	2,070,978	184,962	5,080	353,290	480,563
1908.....	113,002	2,037,203	2,192,188	204,992	4,423	359,003	478,346
1909.....	113,518	2,431,401	2,436,319	189,773	5,213	344,685	491,071
1910.....	110,996	3,119,400	2,584,565	203,596	4,492	351,698	500,978
1911.....	98,611	3,502,762	2,920,725	203,249	2,861	337,583	527,034
1912.....	87,443	4,256,476	3,287,177	233,397	.....	343,883	527,275
1913.....	71,178	4,426,054	3,658,109	228,408	.....	353,260	526,218
.....	.....	.....	.....	.....	.....	.....	.....
1918.....	38,029	3,928,003	2,682,839	817,883	.....	209,172	1,278,157
1919.....	37,353	3,372,753	2,027,375	348,585	.....	142,471	780,923

Year.	Silver. *Kg.*	Silver and Gold Ores.	Sulphur.	Sulphuric Acid.	Tin.	Zinc.		
						Ore.	Metal.	Sulphate.
1903.....	255,722	13	16	724,784	3,042	679,320	182,472	3,586
1904.....	252,020	8	16	868,424	4,193	710,599	192,903	3,696
1905.....	266,072	4	14	921,219	5,196	727,104	198,179	3,506
1906.....	264,427	239	16	980,188	6,570	702,933	205,632	3,630
1907.....	249,348	34	7	1,004,599	5,819	696,039	207,849	3,057
1908.....	274,154	7	706	997,931	5,330	703,394	212,991	3,223
1909.....	271,779	2	1,096	1,006,787	8,943	720,139	214,551	3,434
1910.....	277,777	0.2	1,239	1,164,015	11,345	714,855	216,362	3,875
1911.....	277,981	.....	1,239	1,219,879	12,335	696,903	230,995	4,127
1912.....	.....	.....	.....	.....	.....	647,081	.....	.....
1913.....	.....	.....	.....	.....	.....	649,695	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....
1918.....	.....	.....	.....	.....	.....	488,640	.....	.....
1919.....	.....	.....	.....	.....	.....	313,347	.....	.....

(*a*) From *Zeitschrift für das Berg, Hütten, und Salinenwesen.*
(*b*) Included in "Iron Ore."

MINERAL IMPORTS OF GERMANY (*a*)

Year.	Aluminium Refined and Crude.	Ammonium Sulphate.	Antimony.	Antimony and Arsenic Ores.	Asbestos, Crude.	Asphalt.	Bituminous Rock.	Barium Chloride.	Barytes. (*b*)
1901 ...	1,090	44,408	1,494	1,098	5,500	62,299	41,733	1,768	5,764
1902 ...	1,100	42,252	1,495	1,231	3,415	88,536	36,791	2,135	5,040
1903 ...	1,155	35,168	2,281	1,741	5,727	94,377	40,873	2,374	5,534
1904 ...	2,422	35,166	2,003	1,687	5,251	85,049	38,812	2,428	6,742
1905 ...	3,252	48,005	1,680	567	7,830	3,461	64,196	2,114	7,981
1906 ...	3,886	35,366	2,044	2,417	9,828	15,095	118,238	2,559	17,246
1907 ...	3,974	33,522	2,496	4,913	11,096	4,793	128,257	2,781	12,588
1908 ...	3,204	47,265	2,670	2,073	10,034	2,587	130,063	2,256	19,969
1909 ...	8,696	58,132	2,719	2,912	11,928	1,209	98,378	1,907	14,560
1910 ...	9,892	31,400	2,982	3,347	11,729	2,932	117,763	1,955	5,782
1911 ...	10,454	24,463	3,607	6,429	12,334	133,635	17,476	2,002	7,926
1912 ...	18,112	23,098	3,400	2,891	14,790	147,784	18,409	3,674	18,666
1913 ...	15,508	34,627	3,604	3,700	14,658	145,351	.....	2,598	19,466

Year.	Borax.	Bauxite.	Calcium Carbide.	Cement.	Chalk (*d*), Crude White.	Chrome Ore.	Coal.		Coke.
							Bitum., Arthracite, Cannel.	Lignitie.	
1901 ...	2,537	24,113	9,526	87,262	(*d*)29,611	18,222	6,297,389	8,108,943	400,197
1902 ...	2,057	26,698	11,287	52,018	(*d*)26,408	10,152	6,425,658	7,882,010	382,488
1903 ...	2,567	22,316	14,081	49,870	(*d*)33,362	13,919	6,766,513	7,962,123	432,819
1904 ...	2,603	27,849	14,840	60,188	(*d*)32,581	18,132	7,299,042	7,669,099	550,302
1905 ...	2,802	39,137	17,256	148,118	(*d*)35,529	11,998	9,399,693	7,945,261	713,619
1906 ...	3,044	43,177	22,819	233,119	18,871	17,124	9,253,711	8,430,441	565,561
1907 ...	2,014	59,989	25,834	241,475	16,035	19,508	13,729,849	8,963,103	584,220
1908 ...	1,903	48,064	29,024	168,504	17,606	16,974	11,661,503	8,581,966	575,091
1909 ...	2,550	45,543	26,956	224,178	15,924	22,018	12,198,634	8,166,479	673,012
1910 ...	3,181	56,287	30,712	242,663	17,700	24,470	11,195,593	7,397,719	622,452
1911 ...	5,358	37,155	36,994	253,023	23,717	16,022	10,913,948	7,069,064	598,958
1912 ...	7,978	36,348	47,984	228,896	28,031	23,201	10,380,482	7,266,116	589,713
1913 ...	7,381	38,452	46,725	168,449	32,546	23,251	10,540,018	6,986,681	592,661

Year.	Peat and Peat Coke.	Briquettes.	Cobalt and Nickel Ore.	Copper.				Copperas	Cryolite.
				Ore. and Matte.	Ingots.	Bars, Wire and Sheets.	Sulphate.		
1901 ...	15,102	92,037	12,186	4,614	58,620	786	1,211	501	1,249
1902 ...	16,696	81,854	14,630	14,630	76,050	540	2,499	807	1,332
1903 ...	14,640	84,635	36,927	13,714	83,261	568	1,691	778	1,082
1904 ...	9,071	125,477	14,555	7,949	110,231	719	1,735	765	1,139
1905 ...	11,439	191,753	39,590	10,137	102,218	927	2,180	666	1,143
1906 ...	19,428	162,650	22,557	9,941	126,071	409	1,702	621	(*k*)
1907 ...	15,238	195,403	29,296	19,295	124,116	772	4,519	1,165	(*k*)
1908 ...	15,266	192,391	17,402	17,456	157,669	952	5,078	7,234	(*k*)
1909 ...	13,208	211,058	10,186	26,488	154,673	416	6,550	5,954	(*k*)
1910 ...	16,188	241,267	9,937	22,194	181,551	403	3,952	4,336	(*k*)
1911 ...	14,517	210,933	14,897	23,327	191,590	520	4,145	3,323	(*k*)
1912 ...	11,040	187,736	14,987	23,192	200,608	332	7,074	5,925	(*k*)
1913 ...	11,796	147,416	13,658	27,594	225,392	.....	3,869	2,954	(*k*)

Year.	Gold, Silver and Platinum Ores.	Graphite	Gypsum.	Iodine.	Iron.		Lead.		
					Ore.	Pig.	Ore.	Pig and Scrap.	Lead White.
1901 ...	8,764	17,374	7,622	266	4,370,022	267,503	100,196	52,886	423
1902 ...	6,585	19,392	8,177	220	3,957,403	143,040	71,078	39,006	357
1903 ...	4,386	20,953	8,328	320	5,225,336	158,347	67,573	52,440	442
1904 ...	5,960	23,533	9,550	272	6,061,127	178,256	83,807	61,388	622
1905 ...	6,225	26,143	11,247	377	6,085,196	158,700	92,667	78,528	2,488
1906 ...	4,819	28,175	11,062	297	7,629,730	409,083	90,027	71,191	2,342
1907 ...	3,601	29,405	14,662	147	8,476,076	443,624	137,861	75,200	3,037
1908 ...	1,922	34,491	14,599	194	7,732,949	252,779	133,597	77,218	3,558
1909 ...	1,759	29,191	11,285	369	8,366,599	134,230	111,017	76,930	2,890
1910 ...	2,552	30,733	10,873	363	9,816,822	136,330	112,151	81,541	2,780
1911 ...	2,947	32,812	11,973	303	10,812,595	129,850	143,598	100,515	3,938
1912 ...	2,200	37,633	10,628	260	12,120,090	135,722	122,847	93,585	2,709
1913 ...	1,932	37,168	8,818	258	14,019,045	124,236	142,977	83,781	1,980

Year.	Magnesite.	Manganese Ore.	Mineral Pigments.	Nickel.	Ozokerite.	Petroleum Products		Phosphorus.
						Illuminating Oil.	Lubricating Oil.	
1901....	8,897	204,420	9,403	1,947	1,981	985,904	118,999	313
1902....	12 237	222,010	7,719	1,458	1,585	1,006,829	125,667	350
1903....	14,958	204,647	9,888	1,507	1,663	1,067,697	147,837	222
1904....	15,877	223,709	10,494	1,712	1,300	1,076,324	142,929	220
1905....	19,459	255,760	11,473	1,955	1,114	1,070,252	143,926	198
1906....	25,527	262,311	3,960	3,478	1,303	984,134	180,989	208
1907....	30,857	331,171	2,166	2,182	1,653	1,115,205	226,609	165
1908....	28,305	393,327	1,635	3,058	1,447	1,123,632	216,887	141
1909....	29,994	334,133	13,804	3,745	1,447	1,085,839	216,987	179
1910....	40,218	384,445	15,100	4,606	1,729	1,135,886	230,516	169
1911....	47,930	487,872	15.703	2,598	1,591	955,482	260,242	200
1912....	69,064	420,709	17,874	2,027	1,479	795,011	241,030	205
1913....	64,974	680,371	18,971	3,315	1,363	745,466	248,035	209

Year.	Phosphate Rock.	Potassium Salts.							Pumice Stone.(g)	Pyrite.
		Chloride.	Cyanide. (f)	Iodide.	Nitrate.	Carbonate.	Hydroxide.	Sulphate.		
1901....	351,155	462	2	1,529	1,758	1,529	165	680	2,336	488,633
1902....	430,043	261	3	10	1,889	2,112	42	266	2,070	482,095
1903....	461,092	40	3	8	2,163	1,850	52	81	2,697	519,317
1904....	508,634	47	2	10	2,349	1,955	61	121	3,000	503,503
1905....	501,048	223	3	30	2,156	1,693	24	131	3,240	552,184
1906....	531,195	181	3	18	1,918	2,099	44	257	5,463	579,355
1907....	579,505	1,615	1	8	1,815	2,304	92	141	5,443	742,526
1908....	736,127	49	4	7	2,200	1,773	50	169	6,154	659,871
1909....	663,400	55	2	4	2,853	1,750	64	101	6,639	691,213
1910....	723,271	72	2	8	1,979	2,366	63	66	7,446	792,735
1911....	831,027	1,160	33	13	2,114	2,616	67	61	9,659	862,214
1912....	902,844	46	5	11	597	2,321	62	44	8,365	1,073,285
1913....	928,798	15	3	13	402	2,760	42	44	8,801	1,023,952

Year.	Quicksilver.	Salt.	Slag and Slag Wool.	Sodium Salts.			Strontianite. (n)
				Soda, Calcined.	Nitrate (Chile Saltpeter).	Sulphate and Sulphite.	
1901	651	23,901	733,931	178	529,568	7,921	19,739
1902	648	26,404	831,282	121	467,024	7,308	34,035
1903	674	20,118	877,394	114	467,130	6,058	24,183
1904	691	18,743	846,738	179	506,172	9,598	18,055
1905	729	20,726	888,665	143	540,916	4,752	13,720
1906	698	16,997	813,388	189	593,218	7,405	5,212
1907	831	23,109	568,046	257	591,131	10,446	5,595
1908.	648	24,975	562,853	293	604,457	4,404	4,211
1909	723	19,319	492,771	181	665,450	9,214	4,277
1910	836	30,443	766,320	105	749,945	9,302	4.852
1911	919	29,067	685,943	559	730,939	5,976	3,251
1912	990	17,887	1,248,693	1,987	812,898	5,609	4,259
1913	961	21,422	.....	2,633	774,298	10,074	3,965

Year.	Sulphur.	Sulphuric Acid.	Super-phosphate.	Tin, Crude.	Zinc.			
					Ore.	Spelter.	Drawn or Rolled.	Zinc White, Zinc Gray, Lithophone.
1901....	32,750	18,502	107,365	12,910	75,533	21,250	306	3,673
1902....	32,798	22,205	109,374	13,760	61,407	25,946	134	3,986
1903....	41,545	13,418	82,740	13,925	67,156	25,749	237	4,667
1904....	41,030	16,087	91,288	14,352	93,515	26,389	151	6,461
1905....	39,989	33,837	109,666	13,501	126,577	29,583	54	7,802
1906....	41,390	74,536	76,384	14,098	178,953	39,314	97	9,140
1907....	44,700	59,753	62,877	12,814	184,703	28,459	134	10,189
1908....	44,066	61,391	71,879	14,039	199,840	32,622	286	7,080
1909....	42,941	74,384	80,512	13,537	201,110	44,514	99	7,002
1910....	46,796	86,743	78,873	14,297	240,584	39,328	246	9,239
1911....	46,054	99,653	71,119	14,500	262,399	48,355	467	7,697
1912....	42,284	98,573	62,400	15,550	293,090	56,937	1,003	9,367
1913....	46,737	130,257	53,193	14,261	313,269	57,641	725	9,108

MINERAL EXPORTS OF GERMANY (*a*)

Year.	Aluminium Refined and Crude.	Aluminium Wares, etc.	Aluminium Sulphate.	Ammonium.		Antimony and Arsenic Ores.	Antimony.	
				Carbonate and Chloride.	Sulphate.		Metallic.	Salts.
1901....	282	2,270	31,171	3,196	9,842	283	76	826
1902....	410	2,608	34,005	3,351	5,744	410	105	954
1903....	353	2,865	28,513	2,778	5,592	427	83	873
1904....	407	3,077	29,311	3,106	10,696	486	250	964
1905....	1,192	3,476	34,776	3,579	27,589	287	218	1,097
1906....	1,111	1,321	25,937	3,555	37,288	548	221	997
1907....	1,119	1,142	24,759	3,118	57,439	930	255	1,168
1908....	590	642	22,376	1,161	73,186	588	146	1,030
1909....	492	1,273	58,723	1,093	58,722	577	160	1,090
1910....	616	1,755	93,069	1,500	93,069	571	198	1,047
1911....	768	1,331	30,107	4,895	74,410	612	298	1,208
1912....	2,074	4,184	32,469	5,292	57,268	569	132	1,155
1913....	2,703	5,667	31,772	5,401	75,868	502	702	1,461

Year.	Arsenic.		Asbestos.	Barytes. (*b*)	Barium.		Bauxite.	Borax.	Bromine.
	Metallic.	White, etc.	Crude.		Chloride and Salts of.	White.			
1901 ...	28	1,534	638	67,526	6,803	2,765	137	2,563	228
1902 ...	46	2,036	709	56,026	7,358	2,922	32	2,836	153
1903 ...	32	1,903	513	72,455	8,417	3,187	19	2,779	155
1904 ...	50	1,956	738	69,564	8,596	3,777	21	2,741	208
1905 ...	40	1,753	1,173	81,134	9,550	4,382	6	2,720	156
1906 ...	.....	2,282	1,938	90,819	6,541	10,721	398	2,795	172
1907 ...	(*m*)45	1,733	1,707	111,209	4,189	8,454	517	3,049	118
1908 ...	(*m*)65	1,956	1,345	91,111	3,389	5,190	783	2,379	227
1909 ...	(*m*)54	1,012	1,740	90,555	5,340	4,888	1,116	2,735	206
1910 ...	(*m*)57	1,507	1,537	114,264	6,403	5,528	863	2,916	225
1911...	71	1,973	1,503	128,452	6,180	6,834	960	3,199	229
1912 ...	73	2,400	1,891	142,957	7,389	8,298	400	3,330	187
1913 ...	.....	2,612	1,461	158,065	5,649	7,647	355	3,433	239

Year.	Coke.	Peat and Peat Coke.	Briquets.	Cobalt and Nickel Ore.	Copper.			
					Ore and Matte.	Bars, Sheets and Wire.	Ingots.	Sulphate.
1901....	2,096,931	11,588	529,765	96	26,678	7,700	5,097	1,942
1902..	2,182,383	13,410	697,799	3	17,031	10,599	4,678	1,366
1903....	2,523,351	16,986	895,145	1	15,986	10,715	4,333	1,880
1904....	2,716,855	14,830	917,526	83	19,235	12,594	4,223	2,231
1905....	2,761,080	16,009	936,694	107	28,908	10,006	5,958	2,180
1906....	3,415,347	15,680	1,095,029	(i)	6,414	10,728	7,241	3,018
1907....	3,792,580	25,746	1,260,135	(i)	20,950	13,411	6,113	2,016
1908....	3,577,496	26,817	1,493,054	(i)	21,729	17,209	6,868	2,994
1909....	3,444,791	23,579	1,620,460	(i)	22,437	15,395	6,495	1,290
1910....	4,125,898	20,360	1,988,177	(i)	23,751	19,351	7,654	2,108
1911....	4,555,477	35,855	2,477,492	(i)	27,396	19,669	7,106	3,346
1912....	5,850,350	60,557	2,746,536	(i)	21,514	20,245	7,854	3,812
1913....	6,411,418	86,920	3,163,742	(i)	25,221	.....	7,208	4,013

Year.	Bromine Salts.	Calcium.		Cement.	Chalk, Crude White.	Chromium.		Coal.	
		Carbide.	Chloride.			Ore.	Alum.	Bituminous, Anthracite and Cannel.	Lignitic
1901 ...	249	275	888	560,612	(d)14,134	581	1,299	15,269,267	21,718
1902 ...	357	126	1,346	699,378	(d) 8,475	846	1,758	16,101,141	21,766
1903 ...	435	335	1,831	742,381	(d)12,211	37	1,921	17,389,934	22,499
1904 ...	411	608	2,381	635,248	(d)11,359	47	2,432	17,996,726	22,135
1905 ...	634	709	2,831	675,664	(d)13,081	43	2,507	18,156,998	20,118
1906 ...	643	545	(l)	736,579	4,287	(h) 36	2,942	19,550,964	18,759
1907 ...	655	918	(l)	692,982	2,919	(h) 149	3,110	20,056,503	22,065
1908 ...	506	844	(l)	528,847	2,108	(h) 110	3,215	21,190,777	27,877
1909 ...	486	968	(l)	611,893	4,395	(h)5,023	3,023	23,350,705	39,815
1910 ...	323	1,482	(l)	725,356	3,359	(h) 386	3,998	24,257,651	62,441
1911 ...	.....	2,120	(l)	845,850	1,537	(h)1,795	2,815	27,412,218	58,071
1912 ...	372	971	(l)	1,056,622	2,890	(h) 778	3,221	31,145,057	56,966
1913 ...	405	.....	(l)	1,129,563	3,409	(h) 681	3,313	34,573,514	60,345

Year.	Copperas.	Cryolite.	Fluorspar.	Graphite.	Gypsum.	Iodine.	Iron.	
							Ore.	Pig.
1901.....	4,125	367	13,436	1,667	40,397	27	2,389,870	150,448
1902.....	4,360	486	14,177	1,691	42,859	24	2,868,068	374,256
1903.....	3,986	349	13,028	1,810	51,874	29	3,343,510	418,072
1904.....	3,514	310	13,540	1,815	55,043	30	3,440,846	225,897
1905.....	4,495	286	15,019	1,971	52,886	27	3,698,563	380,824
1906.....	4,712	(k)	15,493	2,013	63,516	46	3,851,791	479,772
1907.....	6,212	(k)	16,624	2,176	70,737	44	3,904,400	275,170
1908.....	4,393	(k)	14,925	2,469	60,992	51	3,067,737	257,849
1909.....	2,232	(k)	14,534	2,377	63,220	59	2,825,007	471,045
1910.....	2,929	(k)	17,988	3,424	89,590	70	2,952,634	786,854
1911.....	4,151	(k)	23,073	3,822	102,754	73	2,581,698	829,393
1912.....	3,386	(k)	21,145	4,501	108,624	79	2,309,628	1,016,261
1913.....	5,382	(k)	25,523	5,423	132,693	92	2,613,158	782,911

Year.	Lead.					Lime, Chloride of.	Magnesite.	Magnesium Chloride.	Manganese Ore.
	Ore.	Pig and Scrap.	Litharge.	White.	Red.				
1901 ...	891	20,820	4,876	16,966	7,776	32,705	2,485	16,102	5,584
1902 ...	2,024	23,100	4,072	19,070	8,372	29,694	2,955	14,757	4,528
1903 ...	1,270	30,243	5,175	20,765	7,617	28,849	2,812	17,008	11,138
1904 ...	1,312	23,169	5,410	16,638	7,544	30,078	1,917	16,706	5,536
1905 ...	1,496	32,515	4,466	16,478	8,902	30,667	2,552	21,673	4,116
1906 ...	1,915	27,067	2,493	14,022	9,450	29,485	2,843	26,708	2,555
1907 ...	1,296	38,259	4,470	13,651	9,371	24,946	3,264	29,566	3,554
1908 ...	1,189	29,967	5,242	13,733	9,602	23,895	4,021	27,525	2,333
1909 ...	2,556	31,674	4,750	10,583	9,058	27,314	3,702	31,334	4,488
1910 ...	2,382	31,025	4,865	13,595	10,444	24,716	5,399	35,352	4,557
1911 ...	3,746	32,063	5,436	14,962	11,321	27,107	4,496	43,896	9,615
1912 ...	3,273	38,122	6,480	12,750	10,116	32,254	7,132	39,559	7,790
1913 ...	4,458	41,369	6,203	12,402	8,898	36,473	5,857	55,505	9,388

Year.	Mineral Pigments.	Nickel.	Ozokerite.	Petroleum Products. (f)		Phosphorus.	Phosphate Rock.
				Illuminating Oil.	Lubricating Oil.		
1901.....	12,671	390	1,700	655	963	149	2,260
1902.....	14,392	689	1,856	824	1,177	260	1,103
1903.....	15,161	700	2,027	701	1,975	286	4,342
1904.....	16,395	1,203	2,447	760	1,763	236	3,222
1905.....	17,603	1,034	2,757	7,286	1,746	228	3,720
1906.....	4,290	954	509	673	9,982	228	5,484
1907.....	4,097	930	692	770	10,552	165	1,494
1908.....	15,675	1,349	921	1,008	10,852	160	1,196
1909.....	18,130	1,606	1,300	588	11,621	168	5,429
1910.....	19,355	1,381	1,642	472	17,141	160	5,044
1911.....	22,426	1,592	1,295	274	18,905	192	10,591
1912.....	27,313	1,677	1,167	244	19,635	219	7,032
1913.....	30,348	1,673	1,999	.....	.....	192	6,885

Year.	Potassium Salts.						Potassium and Potassium-magnesium Sulphate.	Pumice Stone. (g)	Pyrite.
	Carbonate	Cyanide. (f)	Chloride.	Hydroxide.	Iodide.	Nitrate.			
1901 ...	15,567	2,089	118,959	14,892	145	13,439	37,216	699	23,680
1902 ...	14,041	3,257	106,925	13,804	152	9,734	40,487	691	35,370
1903 ...	13,121	2,017	125,302	13,006	154	9,671	56,455	794	32,611
1904 ...	10,777	3,290	140,765	24,963	174	10,405	64,400	943	30,666
1905 ...	11,963	4,005	156,440	22,246	170	12,140	67,286	939	35,195
1906 ...	12,543	5,049	171,994	21,772	168	11,564	54,557	1,578	35,829
1907 ...	13,314	5,210	173,638	20,254	146	12,668	128,344	2,590	24,183
1908 ...	13,009	4,887	174,345	25,048	127	10,643	181,975	6,055	16,384
1909 ...	13,797	6,283	216,286	27,095	122	12,498	201,393	9,140	11,564
1910 ...	13,099	6,329	266,783	29,094	124	14,728	273,614	7,643	9,871
1911 ...	14,584	6,554	329,751	28,921	133	16,430	392,129	22,075	11,015
1912 ...	12,991	6,715	286,614	26,623	143	14,451	134,079	19,978	27,917
1913 ...	16,271	6,678	393,320	44,113	160	16,058	192,565	4,052	28,214

Year.	Quicksilver.	Salt.	Slag and Slag Wool.	Sodium Salts.					
				Bicarbonate.	Carbonate.	Hydroxide.	Nitrate. (Chile Saltpeter).	Soda, Calcined.	Sulphate and Sulphite.
1901...	27	286,424	27,269	1,086	1,382	4,926	13,481	45,967	45,462
1902...	109	328,324	22,726	954	2,449	5,650	14,737	33,109	56,748
1903...	62	399,184	14,674	1,016	2,982	5,886	17,583	46,086	47,660
1904...	43	347,351	38,587	1,524	3,050	5,084	21,075	43,590	45,506
1905...	48	284,203	28,032	1,881	4,113	5,925	20,531	46,768	54,377
1906...	21	97,878	49,912	2,120	5,860	6,101	22,099	41,598	64,217
1907...	26	92,288	46,680	1,764	2,680	7,462	22,715	36,802	69,231
1908...	26	318,395	74,821	1,713	3,842	7,626	23,549	56,839	78,510
1909...	29	364,107	61,674	1,292	2,968	8,314	28,019	54,493	74,512
1910...	31	370,074	58,832	1,370	5,994	9,295	27,095	56,545	89,208
1911...	36	374,633	88,423	1,598	1,782	10,635	27,937	60,102	89,110
1912...	37	430,137	128,740	1,584	1,057	12,460	27,431	66,760	85,416
1913...	53	432,387	.....	1,869	1,354	13,030	27,507	69,993	83,239

Year.	Sodium and Potassium Salts.		Stassfurt Salts.	Strontium.		Sulphur.	Sulphuric Acid.
	Chromates.	Sulphides.		Carbonate. (n)	Salts.		
1901	2,791	2,763	592,347	384	1,022	621	42,853
1902	2,656	4,565	499,220	762	1,546	576	47,666
1903	2,977	5,845	501,385	819	1,389	1,052	50,109
1904	2,272	5,489	631,762	613	1,207	1,418	52,696
1905	2,133	6,569	852,454	613	1,386	1,198	48,701
1906	2,877	6,730	831,293	1,726	1,578	1,582	52,720
1907	3,016	8,103	839,889	1,462	1,671	1,501	49,950
1908	4,402	6,536	818,677	1,494	1,822	1,765	60,588
1909	4,789	7,596	946,457	2,636	1,832	1,935	63,817
1910	4,246	8,679	1,181,208	2,456	1,275	2,727	66,581
1911	5,193	7,837	1,154,974	595	.....	1,757	64,888
1912	5,167	7,640	.....	1,830	138	1,746	75,962
1913.....	5,667	9,226	.....	1,958	330	3,472	64,968

Year.	Superphosphate.	Tin, Crude.	Zinc.				Zinc White, Zinc Gray and Lithophone.
			Ore.	Spelter and Scrap.	Drawn or Rolled.	Sulphate.	
1900.....	77,118	1,626	34,941	51,899	16,709	382	20,729
1901.....	79,190	1,683	14,002	54,490	16,517	324	24,201
1902.....	77,818	2,271	46,965	70,292	17,015	430	28,400
1903.....	99,672	2,581	40,458	67,057	15,715	264	27,527
1904.....	129,925	2,965	40,488	70,063	17,917	332	26,898
1905.....	115,886	3,259	38,972	67,675	18,982	296	27,877
1906.....	104,713	4,845	42,546	69,142	17,794	426	26,296
1907.....	115,049	4,244	34,863	93,649	21,484	425	30,453
1908.....	125,464	3,707	39,450	75,290	18,661	347	26,372
1909.....	168,988	5,431	51,994	82,225	18,961	342	25,970
1910.....	211,812	7,530	59,440	8,803	26,623	334	36,350
1911.....	221,521	7,582	48,998	81,042	36,093	387	34,419
1912.....	271,349	6,368	51,242	105,328	26,379	.....	44,169
1913.....	282,653	6,437	44,731	109,606	24,965	.....	46,106

(*a*) From *Statistisches Jahrbuch für das Deutsches Reich*. (*b*) Includes celestite. (*d*) Includes precipitated chalk. (*f*) Includes sodium cyanide. (*g*) Includes tripoli. (*h*) Includes nickel ore. (*i*) Included under chromium ore. (*k*) Included under bauxite. (*l*) Included under magnesium chloride. (*m*) Includes all alkali metals. (*n*) Includes witherite.

GREECE

The statistics of mineral production in Greece, according to the latest available reports, are summarized in the following table:

MINERAL PRODUCTION OF GREECE (a)
(In metric tons or dollars; 1 drachma = 20 cents)

Year.	Chrome Ore.	Emery.	Gypsum.	Iron Ore.	Iron Ore, Manganiferous.	Lead, Soft.	Lead Ore, Argentiferous.	Lead, Argentiferous.	Lead, Fume.	Lignite.
1904..	6,530	6,182	117	422,159	108,319	(b)	(b)	15,186	(b)	13,500
1905..	8,900	6,972	57	465,622	89,687	(b)	(b)	13,729	(b)	11,757
1906..	11,530	7,718	85	680,620	96,382	(b)	(b)	12,308	(b)	11,582
1907..	11,730	10,652	105	768,863	92,970	(b)	(b)	13,814	(b)	11,719
1908..	4,350	7,471	61	531,368	65,757	(b)	(b)	15,892	(b)	8,786
1909..	9,600	8,193	208	475,616	54,926	(b)	(c)	14,948	(b)	3,873
1910..	9,450	12,939	243	535,482	50,015	(c)	8,355	16,710	(b)	1,500
1911..	12,915	10,544	1,263	496,731	27,482	.....	182,324	14,283	.....	.....
1912..	6,468	3,359	127	376,931	12,212	.....	175,463	14,489	.....	.....
1913..	6,342	5,560	2,230	310,078	6,323	.....	159,348	18,309	.....	170
1914..	7,059	16,112	639	299,286	1,315	.....	151,581	20,684	.....	20,002
1915..	10,420	14,338	1,648	157,340	1,041	.....	104,905	11,595	.....	39,745
1916..	9,880	19,871	356	84,985	818	.....	95,418	9,424	.....	116,946
1917..	6,750	16,440	44	63,364	509	.....	36,558	1,422	.....	157,956

Year.	Magnesite.			Manganese Ore.	Puzzolan.	Sea Salt.	Sulphur.	Zinc Ore.	
	Crude.	Bricks.	Calcined.					Blende.	Calamine, Calcined.
1904...	9,133	(b)	(b)	8,549	44,644	27,000	1,225	(b)	19,913
1905...	37,063	(b)	(b)	8,171	41,900	25,201	1,126	(b)	22,562
1906...	40,584	(b)	(b)	10,040	30,622	25,167	(b)	(b)	26,258
1907...	55,816	(b)	(b)	11,139	39,637	26,966	(b)	(b)	30,346
1908...	63,079	(b)	(b)	10,750	52,312	23,988	(b)	28,739	24,101
1909...	56,797	294	16,609	5,374	46,238	29,448	(b)	41,656	30,159
1910...	18,073	295	19,982	41	31,609	25,978	(b)	(f)5,845	28,898
1911...	86,956	275	27,530	(e) 733	31,647	26,952	(h)31,905	35,856	30,512
1912...	106,338	496	33,848	(e)8,082	19,400	31,400	(h)31,938	39,585	28,912
1913...	98,517	.....	31,815	(e) 556	24,906	19,215	(h)128,932	30,717	20,646
1914...	136,701	493	28,563	558	28,909	29,717	(h)129,129	32,440	22,308
1915...	159,981	161	27,248	408	13,471	16,856	(h) 12,121	33,121	20,209
1916...	199,484	*Nil*	29,933	3,600	8,564	34,522	(h) 41,495	25,853	12,612
1917...	162,938	*Nil*	14,107	*Nil*	*Nil*	45,560	9,535	14,290	7,258

(a) Statistics up to 1903 communicated by E. Grohmann, Seriphos. Statistics for 1903 and subsequent years from *Statistique du Mouvement Minier de Grèce*. The figures represent sales or shipments. (b) Not reported. (c) No sales, but production of lead ore is reported at 240,013 tons in 1909 and 185,207 tons in 1910. (e) Sales. (f) Production in 1910 was 37,108 tons. (h) Including pyrite.

INDIA

The official statistics of mineral production in British India are summarized in the subjoined table:

MINERAL PRODUCTION OF INDIA (a)
(In metric tons or dollars)

Year.	Amber. (g)	Bauxite.	Coal.	Chromite.	Copper Ore.	Corundum.	Diamonds, Carats.	Gold. (c)	Graphite.	Gypsum.	Iron Ore.	Jade. (e) Cwt.	Lead Ore.	Magnesite.
1906	$3,545	.....	9,940,247	4,445	.....	.....	305.9	$10,852,546	2,642	.....	92,933	116	.....	1,861
1907	1,925	.....	11,325,696	18,596	.....	.....	628.0	10,348,795	2,472	.....	69,829	2,636	.....	189
1908	1,820	.....	12,974,558	4,821	.....	.....	140.8	10,597,404	2,919	.....	73,457	3,211	.....	7,655
1909	1,435	32	12,060,550	9,398	7	41	147.3	10,728,900	3,182	17,579	84,774	2,487	12,534	749
1910	1,415	67	12,249,744	1,765	1,174	249	77.7	10,717,300	4,319	13,751	55,461	1,908	30,999	5,265
1911	665	12	12,919,587	3,865	2,273	312	53.0	10,890,804	4,047	11,109	372,049	2,063	35,738	3,546
1912	895	962	14,942,340	2,936	9,774	392	27.8	11,054,608	*Nil*	21,372	589,508	806	25,924	15,626
1913	145	1,202	16,467,337	5,767	3,871	405	115.7	11,152,408	*Nil*	25,363	376,779	3,281	20,626	16,457
1914	1,370	522	16,729,338	5,982	5,410	63	54.7	11,378,435	*Nil*	22,626	448,741	3,765	34,227	1,707
1915	995	890	17,379,305	3,828	9,028	120	36.0	11,531,671	71	22,926	396,554	3,693	42,964	7,570
1916	.....	762	17,532,103	20,484	2,714	1,898	3.6	11,206,510	1,341	16,286	418,387	3,783	14,197	17,924
1917	3,420	1,385	18,506,143	27,497	20,432	2,104	18.2	10,811,712	105	16,952	419,927	3,961	72,787	18,495
1918	435	1,212	21,055,160	58,670	3,677	2,046	73.3	10,024,670	82	17,016	500,413	3,203	63,527	5,947
1919	3,080	1,709	22,992,348	37,026	33,277	718	311.9	10,977,886	129	28,774	573,826	2,019	70,280	17,402

Year.	Manganese Ore.	Mica.	Monazite.	Petroleum, Gallons.	Rubies, Carats.	Salt.	Saltpeter (Potassium Nitrate.)	Sapphires, Carats.	Silver, Oz.	Talc.	Tin and Tin Ore.	Tungsten Ore.
1906	579,231	2,669	.....	140,553,122	329,692	1,176,269	16,822	(f)	.....	.....	97	.....
1907	916,770	2,652	.....	152,045,677	604,217	1,120,427	18,664	(f)	.....	.....	80	.....
1908	685,135	2,720	.....	176,646,320	356,044	1,300,416	19,620	(f)	.....	.....	96	.....
1909	654,974	1,671	.....	233,678,087	265,010	1,274,682	20,953	(f)	27,500	593	85	7
1910	813,721	1,153	.....	214,928,647	262,019	1,577,823	16,140	(f)	49,680	250	167	402
1911	681,015	1,722	.....	225,792,094	288,213	1,347,116	14,679	(f)	103,580	934	189	1,329
1912	643,209	2,227	.....	249,083,518	323,245	1,477,971	14,797	(f)	93,476	800	382	1,697
1913	828,088	2,324	1,253	277,555,225	203,925	1,496,760	14,461	21,353	125,209	2,564	359	1,713
1914	693,824	2,057	1,205	259,342,710	193,333	1,529,002	15,738	56,709	236,446	1,015	374	2,363
1915	457,668	1,379	1,126	287,093,576	167,904	1,956,311	18,389	39,718	285,387	1,094	568	2,687
1916	655,592	2,205	1,313	297,189,787	136,783	1,512,616	25,459	34,100	759,012	1,236	589	4,057
1917	600,325	2,078	1,972	282,759,523	132,409	1,634,519	21,627	32,369	1,581,838	7,955	820	4,615
1918	526,231	2,778	2,151	286,585,011	101,637	2,075,164	25,139	34,949	1,971,783	4,611	896	4,502
1919	546,657	2,326	2,056	305,651,816	88,847	1,921,585	17,833	47,286	2,165,607	2,169	1,505	3,635

(a) Records of the Geological Survey of India. (b) Not reported. (c) £1 = $4.866. (d) Production of iron ore in Bengal only. (e) Exports in cwt. of 112 lb. (f) Included in rubies. (g) £1 = $5.

ITALY

The following tables itemize the statistics of the production and the foreign commerce of mineral and metallurgical products in Italy:

MINERAL PRODUCTION AND REFINED PRODUCTS OF ITALY (a)
(In metric tons or dollars; 5 lire = $1)

Year.	Alum.	Aluminium Sulphate.	Alunite.	Antimony.	Antimony Ore.	Asphalt, Mastic, and Bitumen.	Asphaltic Rock.	Barytes.
1906.....	2,878	2,800	7,500	537	5,704	34,386	130,225	12,020
1907.....	3,175	3,010	7,600	610	7,892	38,568	161,126	15,732
1908.....	2,875	2,100	6,165	345	2,821	34,761	134,163	15,432
1909.....	2,580	2,750	5,636	59	1,077	39,165	111,067	16,240
1910.....	2,510	2,773	6,081	*Nil*	2,194	41,705	162,212	14,420
1911.....	2,725	2,493	6,100	*Nil*	2,441	50,179	188,133	13,620
1912.....	1,299	2,727	6,002	*Nil*	1,878	52,707	181,397	13,420
1913.....	1,009	3,308	5,976	76	1,822	56,750	171,097	12,970
1914.....	1,307	3,229	3,700	138	555	33,752	119,853	12,970
1915.....	1,329	2,094	4,850	548	4,334	25,701	47,650	17,850
1916.....	(b)	(b)	3,370	660	6,509	16,662	16,829	21,650
1917.....	(b)	(b)	4,855	535	5,789	13,608	8,645	19,000
1918.....	(b)	(b)	2,217	367	3,369	8,310	22,309	14,945
1919.....	(b)	(b)	3,507	10	25	14,872	78,000	19,390
1920.....	(b)	(b)	.....	.....	.....	.....	108,600	.....

Year.	Borax, Refined.	Boric Acid.		Coal. (c)	Coal (Briquettes).	Coke.	Copper.		
		Crude.	Refined.				Ore.	Ingot, etc.	Sulphate.
1906...	1,062	2,561	562	473,293	829,277	672,689	147,137	15,456	34,270
1907...	880	2,305	466	453,137	787,087	717,704	167,619	17,491	45,263
1908...	1,024	2,520	429	480,029	822,699	813,842	106,629	18,280	42,598
1909...	1,110	2,431	578	555,073	924,479	999,381	90,272	20,005	28,551
1910...	912	2,502	695	562,154	918,055	1,160,543	68,369	22,467	36,236
1911...	738	2,648	444	555,137	794,206	363,493	68,136	22,908	44,626
1912...	813	2,309	760	663,812	876,565	437,706	86,001	26,659	52,311
1913...	1,070	2,410	743	701,079	896,091	1,336,382	89,487	24,625	44,497
1914...	1,164	2,537	838	781,288	968,600	1,276,318	88,953	1,839	31,302
1915...	829	2,497	1,277	953,082	721,409	1,365,109	74,470	1,840	41,272
1916...	(b)	2,293	1,114	1,305,840	(b)	(j)515,561	88,475	1,867	(b)
1917...	(b)	2,335	(b)	1,722,157	(b)	(j)447,387	86,842	1,248	(b)
1918...	(b)	2,210	(b)	2,171,397	(b)	(j)262,515	82,302	1,114	(b)
1919...	(b)	2,063	(b)	1,317,923	(b)	(j)302,737	16,679	1,243	(b)
1920...	(b)	.....	(b)	1,833,745	(b)	.....	6,360	.....	(b)

Year.	Gold.		Graphite.	Iron and Steel.				
	Ore.	Bullion.		Ore.	Pig.	Bar, Sheet, Pipe, Wire, etc.	Tin Plate.	Steel.
1906.....	6,543	$ 42,720	10,805	384,217	180,940	236,946	16,350	332,924
1907.....	13,475	41,000	10,989	517,952	148,996	248,157	24,423	346,749
1908.....	14,671	48,223	12,914	539,120	158,100	302,509	28,277	437,674
1909.....	2,890	18,230	11,583	505,095	254,904	281,098	35,880	608,795
1910.....	2,147	11,746	12,510	551,259	399,700	311,210	42,670	670,983
1911.....	2,080	16,440	12,621	373,786	302,931	303,223	25,662	697,958
1912.....	2,366	13,271	13,170	582,066	379,989	179,516	28,916	801,907
1913.....	2,047	23,580	11,145	603,116	426,755	591,763	29,185	846,085
1914.....	205	(b)	8,567	706,246	385,340	705,273	26,284	796,152
1915.....	296	1,420	6,176	679,970	377,510	(b)	29,094	1,009,240
1916.....	*Nil*	(b)	8,182	942,244	467,005	(b)	(b)	1,269,486
1917.....	*Nil*	(b)	12,117	993,825	471,188	(b)	(b)	1,331,641
1918.....	(b)	(b)	11,653	693,872	313,576	(b)	(b)	992,523
1919.....	(b)	(b)	7,626	613,025	239,710	(b)	(b)	731,823
1920.....	(b)	(b)	4,190	423,300	.....	(b)	(b)	.....

Year.	Lead.		Magnesite.	Manganese Ore.	Manganiferous Iron Ore.	Marble.	Petroleum. Crude.	Refined Petroleum, Benzene, etc.
	Ore.	Pig.						
1906	40,945	21,268	.....	3,060	20,500	430,202	7,452	10,954
1907	(d)43,037	22,978	.....	3,654	18,874	434,512	8,326	10,556
1908	36,649	26,003	.....	2,750	17,812	425,690	7,088	10,876
1909	37,945	22,133	.....	4,700	25,830	391,295	5,895	11,077
1910	36,840	14,495	.....	4,200	25,700	427,274	7,069	12,149
1911	39,008	16,684	.....	3,515	6,482	497,741	10,390	15,569
1912	41,680	21,450	.....	2,641	*Nil*	522,088	7,479	13,792
1913	44,654	21,674	600	1,622	*Nil*	509,342	6,572	11,160
1914	45,538	20,464	1,140	1,649	*Nil*	431,087	5,542	11,873
1915	41,590	21,812	9,200	12,577	*Nil*	246,883	6,105	14,332
1916	39,460	24,362	18,252	18,147	4,360	200,700	7,035	20,467
1917	39,076	16,237	31,070	24,532	4,806	134,233	5,668	4,370
1918	37,583	18,332	28,882	31,896	805	87,483	4,907	3,668
1919	33,212	16,530	35,930	30,841	68	265,774	4,851	3,544
1920	36,325	.....	.....	29,140	.....	.....	4,750	.....

Year.	Pumice Stone.	Pyrite (Cupriferous in Part).	Quicksilver.		Salt.			Silver, Bullion. *Kg.*
			Ore.	Metal.	Brine.	Rock.	Sea.	
1906	16,366	122,364	80,638	417	13,751	19,007	496,872	20,362
1907	11,500	126,925	76,561	434	19,238	31,540	454,454	20,502
1908	15,000	131,721	82,534	684	15,180	24,033	473,857	20,746
1909	10,000	149,084	97,592	771	15,081	28,026	421,362	20,534
1910	12,900	165,688	87,129	894	16,600	39,197	447,440	14,237
1911	16,430	165,273	97,803	955	17,251	43,763	460,439	12,143
1912	17,386	277,585	88,200	1,000	18,775	39,954	466,220	14,363
1913	14,793	317,334	109,379	1,004	17,727	41,323	750,518	13,094
1914	14,376	335,531	119,223	1,073	18,396	41,715	762,040	15,254
1915	10,242	369,320	110,642	985	17,914	33,267	627,050	15,362
1916	9,287	410,290	132,524	1,093	16,943	50,294	330,013	15,131
1917	11,312	500,782	(b)	1,071	12,733	43,042	322,666	10,679
1918	4,473	482,060	(b)	1,038	13,979	41,947	417,524	10,115
1919	13,210	372,574	(b)	845	21,376	41,313	473,059	8,240
1920	.....	318,050	(b)	1,325	.....	.....	.....	.....

Year.	Sulphur.			Talc, Ground.	Zinc.	
	Crude (Fused).	Ground.	Refined.		Ore.	Spelter.
1906	499,814	176,476	170,990	7,894	155,751	69
1907	426,972	151,338	160,617	8,850	160,517	188
1908	445,312	160,693	156,995	9,410	(e)152,254	(b)
1909	435,060	132,531	144,579	9,530	(g)130,890	(b)
1910	430,366	171,570	169,093	11,580	(g)146,307	(b)
1911	414,161	158,977	166,802	14,156	139,719	(b)
1912	389,451	164,864	168,514	14,324	149,776	(b)
1913	386,310	(k)20,096	151,713	21,350	158,278	(b)
1914	377,843	(k)25,715	149,100	22,478	145,914	(b)
1915	358,107	(k)22,133	116,358	21,942	80,622	(b)
1916	269,374	(k)18,591	(b)	25,933	94,043	258
1917	211,847	(k)18,227	(b)	20,811	79,453	367
1918	234,296	19,094	(b)	17,369	67,116	1,188
1919	226,126	29,190	(b)	17,184	85,778	1,282
1920	258,000	35,000	(b)	.....	98,090	.....

(a) From *Rivista del Servizio Minerario*. (b) Not reported. (c) Includes anthracite, lignite, fossil wood, and bituminous schist. (d) Does not include 680 tons lead and zinc ore. (e) Includes 560 tons lead-zinc ore. (g) Includes 290 and 300 tons lead-zinc ore, 1909 and 1910. (j) Metallurgical coke only. (k) Crude, ground.

MINERAL IMPORTS OF ITALY (a)

(In metric tons or dollars; 5 lire = $1)

Year.	Antimony.	Arsenic. Kg.	Asbestos.	Asphaltum.	Barytes.	Borax and Boric Acid.	Cement and Hydraulic Lime.	Lime.
1905.....	117	3,400	1,806	3,252	1,444	112	15,797	5,556
1906.....	50	5,300	2,171	2,854	1,400	163	18,937	7,714
1907.....	163	3,100	3,110	3,661	1,540	307	29,024	6,156
1908.....	153	2,800	2,548	3,730	1,523	333	28,935	7,210
1909.....	293	4,800	2,285	3,826	2,094	386	25,250	11,120
1910.....	342	5,300	2,051	3,365	1,777	363	22,183	9,007
1911.....	358	5,500	3,892	4,238	2,024	741	24,467	7,942
1912.....	636	4,600	4,080	3,548	1,986	380	23,423	6,809
1913.....	513	2,500	4,750	4,300	1,771	159	19,950	5,501
1914.....	198	3,500	2,710	2,924	1,409	280	15,002	3,810
1915.....	825	1,700	5,380	4,139	1,319	719	5,969	2,052
1916.....	155	2,700	5,428	1,090	1,398	985	6,606	2,943
1917.....	1,247	*Nil*	3,729	1,381	1,121	632	64,809	1,408
1918.....	1,164	*Nil*	3,165	2,111	1,064	350	5,365	634
1919.....	555	3,100	3,650	4,663	795	564	11,572	95
1920.....	293	11,100	3,968	1,750	1,545	1,316	15,789	7

Year.	Coal. (c)	Copper, Ore.	Copper, Cement.	Copper, Brass and Bronze.	Copper and Iron Sulphates.	Gold. Kg.	Graphite.
1905.....	6,437,539	6,879	486	18,188	30,684	5,768	107
1906.....	7,673,435	9,363	802	21,458	25,060	4,571	361
1907.....	8,300,439	18,023	888	28,937	15,939	4,443	267
1908.....	8,452,320	14,784	344	28,025	25,037	(d) 8,367	383
1909.....	9,303,506	11,303	630	22,391	9,137	(d) 8,311	141
1910.....	9,338,752	7,550	456	30,339	13,599	(d)13,188	229
1911.....	9,595,882	6,607	277	38,650	37,929	(d)12,712	246
1912.....	10,057,228	6,253	578	43,729	36,602	(d)10,545	403
1913.....	10,834,008	737	352	39,552	30,472	(d) 9,940	567
1914.....	9,758,877	850	*Nil*	28,422	21,939	(d)10,281	162
1915.....	8,369,029	571	*Nil*	54,718	14,081	(d) 6,389	1,506
1916.....	8,065,041	2,453	*Nil*	68,365	6,126	(d) 343	1,071
1917.....	5,037,497	467	*Nil*	93,115	231	96	1,219
1918.....	5,840,922	404	502	79,594	23	149	1,011
1919.....	6,226,451	31	*Nil*	79,429	2,466	1,324	895
1920.....	5,619,978	*Nil*	*Nil*	22,584	857	1,771	1,617

Year.	Iron.		Iron and Steel Scrap.	Lead.		Lead Oxide and Carbonate.	Mineral Paints.
	Ore.	Pig.		Ore. (c)	Metal and Alloys in Pigs.		
1905.....	4,745	136,077	276,311	465	6,764	686	974
1906.....	6,452	168,985	344,977	4,526	10,958	984	964
1907.....	22,046	231,042	362,567	4,342	9,231	953	1,119
1908.....	31,090	254,239	326,119	5,620	11,742	1,474	2,616
1909.....	28,150	246,730	416,354	3,003	10,011	1,132	1,713
1910.....	17,673	204,854	386,604	1,426	14,674	1,225	1,775
1911.....	50,554	234,770	392,703	6,042	20,187	1,077	1,756
1912.....	18,606	267,355	343,728	12,391	15,627	917	1,962
1913.....	8,026	221,688	326,231	9,552	11,494	682	2,410
1914.....	4,592	219,995	254,892	5,736	9,820	533	2,053
1915.....	7,607	240,535	261,468	6,181	17,326	183	1,811
1916.....	1,237	302,333	342,706	12,551	14,358	224	1,130
1917.....	313	315,953	227,234	4,838	26,283	38	481
1918.....	4,952	115,211	17,667	5,478	40,310	29	362
1919.....	12,553	216,138	96,247	4,672	17,917	75	510
1920.....	1,607	157,193	142,857	3,684	1,510	398	1,307

Year.	Nickel Alloys and Manufactures.	Petroleum.	Phosphate Rock.	Potash, Ammonia, and Caustic Soda.	Potassium Sulphate.	Quicksilver.	Silver. *Kg.*	Slag, Metalliferous.
1905.....	574	66,493	240,144	17,752	1,804	57	20,697	72,785
1906.....	717	64,541	307,762	16,718	1,534	12	20,410	88,118
1907.....	725	72,715	384,896	15,225	3,866	11	21,829	5,378
1908.....	1,079	82,373	531,921	14,962	4,891	10	(*d*)83,434	1,122
1909.....	540	88,929	478,199	15,547	5,333	2.2	(*d*)47,234	878
1910.....	1,311	84,748	422,714	16,983	7,753	2.5	(*d*)55,516	3,153
1911.....	1,584	119,245	479,042	16,312	9,493	2.0	(*d*)52,576	95
1912.....	1,742	113,231	466,144	17,816	13,466	1.5	(*d*)79,763	164
1913.....	1,200	115,374	529,776	17,407	9,454	0.3	(*d*)87,856	2,560
1914.....	1,112	116,276	513,998	16,382	3,708	*Nil*	102,090(*d*)	700
1915.....	1,812	111,426	456,901	21,977	900	4.3	(*d*)83,018	1,780
1916.....	1,991	97,747	431,425	19,878	*Nil*	42.0	(*d*)50,859	1,116
1917.....	3,293	94,183	230,159	17,860	*Nil*	*Nil*	(*d*)65,966	133
1918.....	3,215	72,238	232,129	15,219	*Nil*	*Nil*	(*d*)10,924	22
1919.....	2,136	94,333	449,317	11,887	*Nil*	*Nil*	(*d*)18,578	118
1920.....	212	121,535	400,001	28,073	1,005	*Nil.*	(*d*) 5,216	330

Year.	Sodium Salts.		Sod. and Pot. Nitrates, Refined.	Tin.		Zinc.			
	Carbonate.	Nitrate (Crude).		Block.	Mnfrs.	Ore.	Oxide.	Spelter and Old.	Mnfrs.
1905.....	29,066	46,517	689	2,304	103	14	1,246	5,997	4,701
1906.....	31,170	32,508	395	3,361	167	2,042	1,920	6,835	4,421
1907.....	35,538	41,457	668	2,771	183	11	1,962	8,152	5,407
1908.....	38,268	60,784	428	2,602	187	7	2,026	9,339	5,112
1909.....	38,252	43,658	532	2,555	191	13	1,571	9,222	4,572
1910.....	45,174	61,192	1,083	2,760	238	18	2,001	8,971	5,416
1911.....	45,596	59,561	417	2,524	211	428	2,100	10,742	5,892
1912.....	49,284	54,634	529	2,627	157	*Nil*	2,550	11,955	5,833
1913.....	52,332	67,418	574	2,973	144	5	2,983	12,448	6,071
1914.....	48,115	59,850	310	2,744	110	*Nil*	2,348	10,518	4,302
1915.....	53,191	71,730	2	4,245	38	*Nil*	1,833	12,843	1,087
1916.....	45,212	85,649	103	2,916	32	*Nil*	1,376	17,766	1,017
1917.....	29,583	104,150	115	3,254	8	*Nil*	806	18,421	974
1918.....	22,651	97,012	846	2,335	6	*Nil*	415	10,204	641
1919.....	27,235	12,868	71	2,841	44	*Nil*	1,515	16,012	3,282
1920.....	34,252	49,204	534	2,063	169	*Nil.*	2,637	3,769	3,445

MINERAL EXPORTS OF ITALY (*a*)

(In metric tons or dollars; 5 lire = $1)

Year.	Antimony.	Asbestos.	Asphaltum.	Barytes.	Borax and Boric Acid.	Cement and Hydraulic Lime.	Lime.	Coal. (*e*)
1905.....	132	236	23,740	162	2,255	8,445	4,194	38,555
1906.....	208	205	27,176	147	2,777	6,774	3,118	31,666
1907.....	115	142	26,036	152	1,330	4,477	3,224	40,769
1908.....	10	193	24,158	724	1,005	5,439	2,533	46,774
1909.....	8	527	21,978	125	1,704	7,534	3,525	51,343
1910.....	2	485	26,125	150	1,536	7,131	5,764	48,144
1911.....	*Nil*	517	28,455	353	1,347	10,742	9,440	40,800
1912.....	11	571	13,158	381	1,661	55,091	6,736	26,298
1913.....	*Nil*	672	6,645	234	1,373	55,908	5,161	192,002
1914.....	51	509	6,367	210	1,195	40,880	5,161	54,908
1915.....	3	148	6,720	3,288	1,702	40,430	627	79,090
1916.....	188	259	4,103	2,755	2,098	42,425	114	94,319
1917.....	40	166	111	1,113	1,113	8,474	180	77,432
1918.....	*Nil*	118	1	523	1,335	1,319	617	59,157
1919.....	111	141	430	1,977	1,786	11,370	619	83,657
1920.....	843	294	2,357	4,298	1,279	12,515	300	77,061

Year.	Copper, Ore.	Copper and Iron Sulphate.	Gold. *Kg.*	Graphite.	Iron.		
					Ore.	Pig.	Scrap.
1905	77	249	1,731	6,811	11,358	1,395	.....
1906	189	102	1,476	4,904	1,833	254	.....
1907	179	835	802	7,474	26,000	121	.....
1908	188	721	7,588	7,009	35,653	176	1,676
1909	233	1,211	15,452	8,125	46	209	1,480
1910	969	741	16,643	7,647	9,892	327	2,450
1911	130	157	14,144	7,633	22,851	290	3,390
1912	267	1,445	13,993	7,785	12,313	51	5,662
1913	285	609	16,440	8,329	9,660	555	6,895
1914	78	1,856	6,724	7,589	8,944	69	4,636
1915	2	62	1,072	6,508	157	40	2,576
1916	*Nil*	170	632	5,615	30	2	13
1917	20	403	108	7,992	327	5	162
1918	*Nil*	338	3	7,310	66	20	*Nil*
1919	*Nil*	1,274	104	2,185	1,679	53	*Nil*
1920	1,978	5,875	47	3,769	381	42	1,604

Year.	Lead.			Mineral Paints.	Phosphate Rock.	Quicksilver.	Salt.	Silver. *Kg.*
	Ore.	Lead Alloys, in Pigs.	Oxide and Carbonate.					
1905	4,311	976	310	3,632	3,519	243	116,040	25,947
1906	8,356	2,005	315	4,502	1,652	278	126,199	18,262
1907	3,213	1,548	240	4,602	4,560	350	99,191	18,164
1908	2,041	1,243	219	3,446	2,271	565	85,489	(*d*)28,716
1909	1,037	782	211	4,310	2,979	714	103,895	(*d*)87,653
1910	4,122	933	197	3,945	3,627	781	122,404	(*d*)22,403
1911	15,791	637	196	4,182	5,427	1,037	119,173	(*d*)28,434
1912	17,062	4,122	75	4,417	1,285	993	155,543	(*d*)28,275
1913	16,950	577	314	4,166	4,171	993	161,118	(*d*)18,786
1914	15,403	189	687	4,220	8,569	760	124,860	(*d*)12,233
1915	3,817	14	339	3,458	1,809	853	108,991	(*d*)28,016
1916	9,871	4	1,582	2,766	*Nil*	767	31,135	(*d*) 4,898
1917	7,622	3	512	1,360	*Nil*	1,115	1,013	(*d*) 1,364
1918	5,845	2	16	866	5	1,219	10,818	(*d*) 737
1919	5,600	502	225	770	*Nil*	492	37,197	(*d*) 7,333
1920	9,858	3,564	1,678	2,043	5	1,029	126,671	(*d*)20,021

Year.	Slag.	Sodium Salts.			Sulphur.	Tin.		Zinc.		
		Carbonate	Nitrate (Crude).	Sod. and Pot. Nitrates, Refined.		Block.	Manufactures	Ore.	Oxide.	Spelter and Scrap.
1905	9,844	214	424	159	381,128	285	107	117,810	173	434
1906	8,990	253	80	133	336,339	303	81	144,244	687	639
1907	10,934	200	138	102	297,378	434	117	142,271	727	1,182
1908	12,122	583	37	57	330,093	180	173	122,456	395	984
1909	17,163	517	464	163	329,233	85	126	123,936	212	983
1910	10,488	321	98	45	344,513	164	245	127,315	957	845
1911	8,274	180	168	15	398,592	166	319	133,471	1,577	616
1912	19,563	243	27	7	376,387	83	359	152,840	2,165	1,222
1913	8,251	337	50	10	351,339	152	394	144,644	1,313	1,566
1914	7,822	123	179	12	260,333	179	313	89,776	1,219	1,234
1915	715	94	*Nil*	5	393,908	36	364	59,734	2,560	86
1916	495	31	*Nil*	108	326,435	100	388	80,180	1,294	126
1917	30	30	*Nil*	*Nil*	118,340	1	130	50,355	508	13
1918	300	25	*Nil*	*Nil*	192,227	2	25	50,551	115	5
1919	160	26	3	*Nil*	120,458	46	47	57,877	114	5
1920	192	67	51	8	148,046	159	123	93,543	1,652	79

(*a*) From *Statistica del Commercio speciale di Importazione e di Esportazione.* (*b*) Not reported. (*c*) Includes argentiferous lead ore. (*d*) Includes coin, bullion, sheets, leaf, and partly manufactured. (*e*) Includes coke.

JAPAN

The total mineral production of the Japanese Empire, according to the latest available returns, is shown in the following table, in metric tons, unless otherwise specified. Figures in full-faced type are either provisional figures or estimates.

MINERAL PRODUCTION OF JAPAN (a)

Year.	Antimony.		Arsenic.	Coal.	Copper.	Gold.	Graphite	Pig. Iron.	Lead.
	Ore.	Metal.	*Kg.*			*Kg.*			
1902....	88	528	12,188	9,588,910	29,034	2,975	97	32,130	1,644
1903....	153	434	6,000	10,088,845	33,245	3,140	114	33,870	1,728
1904....	104	321	4,000	10,723,796	33,187	2,765	216	38,143	1,803
1905....	96	190	8,333	11,955,946	35,944	3,048	209	53,210	2,272
1906....	97	627	5,250	13,468,529	36,963	2,873	177	57,373	4,305
1907....	(b)	248	7,491	13,764,731	40,183	2,938	103	44,447	3,079
1908....	(b)	198	19,838	14,767,638	41,399	3,598	177	42,007	2,910
1909....	10	157	8,061	14,810,412	45,117	3,932	121	46,627	3,337
1910(d)	8	120	11,463	15,433,621	48,545	4,368	145	58,043	3,845
1911(d)	.....	97	5,760	17,632,710	53,401	4,690	114	63,986	4,125
1912....	.....	80	.....	19,515,285	62,939	5,233	149	56,265	3,764
1913....	.....	(d)21	.....	21,664,764	66,537	4,666	(d)665	57,513	3,779
1914....	.....	3,865	.....	22,296,738	70,481	7,068	574	73,909	4,563
1915....	8,390	8,347	14,885	20,490,702	75,415	8,293	666	64,897	4,764
1916....	12,402	**12,398**	.....	20,130,740	81,280	7,446	1,144	65,014	11,343
1917....	.....	**6,678**	.....	**26,510,137**	**91,201**	**7,077**	**1,329**	.....	**15,807**

Year.	Manganese Ore.	Petroleum. *Gallons.*	Phosphates.	Pyrite.	Quicksilver. *Kg.*	Salt. *Hectoliters.*	Silver. *Kg.*	Sulphur.	Tin.
1902....	10,844	39,056,820	196	18,580	1,418	11,042,192	57,635	18,287	18.6
1903....	5,616	34,850,129	191	16,149	206	6,574,890	58,704	22,914	19.0
1904....	4,324	50,724,174	13	24,886	*Nil.*	7,019,650	61,339	25,587	25.0
1905....	14,017	51,573,754	1,519	25,569	349	(b)	82,886	24,652	26.0
1906....	54,339	47,132,800	3,037	36,038	336	(b)	76,247	27,589	77.0
1907....	20,586	60,005,957	1,721	56,166	456	(f)636,168	95,600	33,329	31.8
1908....	11,130	60,110,558	740	33,867	804	(f)659,202	123,180	33,149	25.7
1909(d) .	8,708	65,165,860	3,781	27,066	335	(f)696,049	127,917	36,317	22.8
1910(d) .	11,120	65,789,858	1,042	78,418	407	(f)696,474	141,613	43,155	23.0
1911....	9,787	63,843,601	2,271	73,879	1,021	(g)567,715	138,287	50,274	24.8
1912....	12,060	72,839,260	7,847	74,929	27	.....	152,385	55,005	35.6
1913....	2,313	67,557,322	19,047	114,589	.....	.....	146,180	59,481	379.0
1914....	17,076	112,163,530	38,252	115,840	.....	.....	150,958	59,850	245.0
1915....	25,870	124,277,191	57,723	67,536	38	.....	159,261	61,405	341.0
1916....	.....	120,111,856	114,389	91,102	204	.....	172,194	92,677	**255.0**
1917....	**51,366**	**119,706,678**	**121,609**	**121,349**	**2,000**	.....	**221,196**	**117,990**	**212.0**

(a) From *Résumé Statistique de l'Empire du Japan*, Tokio. (b) Not reported. (d) From reports of the Japanese Department of Agriculture and Commerce. (f) Metric tons including Taiwan, fiscal years. (g) Metric tons; from *Résumé Statistique de l'Empire du Japan.*

MEXICO

Statistics showing the production of metals in Mexico since 1916 have been prepared by the Mexican Secretariat of Industry, Commerce, and Labor.

PRODUCTION OF METALS IN MEXICO
(In metric tons)

Year.	Antimony.	Arsenic	Copper.	Gold, Kg.	Graphite.	Lead.	Manganese.	Quicksilver.	Silver, Kg.	Tungsten.	Zinc.
1916...	829	.....	28,411	11,748	470	19,971	.....	.....	926,142	12	37,449
1917...	2,647	1,285	50,986	23,543	420	64,125	73	33	1,306,988	188	14,757
1918...	3,269	1,881	70,223	25,313	6,191	98,837	2,878	164	1,944,542	149	20,699
1919...	471	2,246	56,172	23,586	4,023	71,376	2,294	119	2,049,898	22	11,560
1920...	1,572	1,119	46,057	23,370	2,992	121,434	839	77	1,979,972	35	14,363

MINERAL EXPORTS OF MEXICO (a)
(In metric tons or Mexican dollars)

Year.	Antimony.		Coal.	Copper.		Gold, Dollars.				
	Metal.	Ore.		Ore.	Ingot.	Ore.	Bullion.	Specie.	Cyanide.	Sulphide.
1906...	2,418	178	91	73,193	46,767	$5,369,173	$21,072,014	$37,746	$337,294	$180,348
1907...	4,615	681	1,532	115,245	51,519	3,033,090	19,653,362	5,023,404	417,162	497,893
1908...	4,046	36	719	70,900	26,214	2,746,289	30,101,546	42,389	144,959	334,944
1909...	4,115	31	235	136,031	32,580	2,346,279	40,725,976	23,678	85,110	250,741
1910...	3,730	6	120	129,568	54,061	2,526,444	46,189,613	37,723	46,803	168,162
1911...	4,131	121	101	109,627	60,493	1,945,660	48,113,427	8,153,293	38,031	141,640
1912...	3,491	15	50,777	103,129	60,439	1,121,333	42,686,667	1,479,292	43,481	119,357
1913...	2,340	(b)	40	19,500	29,438	785,531	32,918,172	470,758	54,417	172,188

Year.	Graphite.	Gypsum.	Lead.		Silver, Dollars.					
			Ore.	Base Bullion.	Ore.	Bullion.	Specie.	Sulphide.	Cyanide.	Slag.
1906...	3,915	(b)	(b)	73,699	$9,619,763	$63,057,152	$42,390,357	$595,112	$434,885	(b)
1907...	3,202	(b)	11	76,158	11,396,844	68,187,169	23,848,571	785,116	483,638	(b)
1908...	1,076	(b)	26	127,010	11,230,372	63,298,659	60,405	791,698	68,849	(b)
1909...	1,704	(b)	1	118,186	8,057,189	66,789,716	91,006	557,520	78,688	(b)
1910...	2,332	1	355	120,662	6,793,896	70,272,894	72,891	208,300	52,053	(b)
1911...	2,974	(b)	397	124,605	6,766,644	78,515,378	8,901	235,410	159,170	Nil
1912...	2,865	(b)	59	109,717	5,769,575	82,047,500	8,645	(d)	347,277	Nil
1913...	1,057	(b)	1,386	55,530	2,108,805	63,232,843	2,585,701	423,625	418,522	(b)

(a) From the *Estadistica Fiscal*. The figures for the calendar years were arrived at by combining those of the successive semesters of the different fiscal years. (b) Not reported. (d) 11 metric tons.

NORWAY

The official statistics of mineral production, imports and exports are summarized in the following tables:

MINERAL PRODUCTION OF NORWAY (a)

(In metric tons or dollars; 1 Krone = 27 cents)

Year.	Apatite. (b)	Chrome Ore.	Copper.		Feldspar.	Gold.	Iron.		
			Ore.	Ingot.			Ore and Conc.	Pig and Cast.	Bars and Steel.
1906...	3,482	*Nil.*	32,203	1,333	23,896	$5,400	109,259	257	317
1907...	1,830	107	39,887	1,517	32,970	*Nil.*	140,804	*Nil.*	283
1908...	1,771	*Nil.*	33,688	1,806	34,437	*Nil.*	119,656	.....	.....
1909...	1,364	*Nil.*	42,612	1,594	36,439	8,000	40,389	.....	.....
1910...	703	.....	46,308	1,814	39,507	5,000	102,447	.....	.....
1911...	897	.....	34,705	1,650	34,864	.....	220,524	316	.....
1912...	1,168	115	60,018	2,130	39,844	.....	408,092	309	.....
1913...	757	.....	70,349	2,741	40,842	2,200	544,686	346	.....
1914...	750	81	57,951	2,860	27,967	.....	652,273	6,909	.....
1915...	1,901	350	56,097	2,828	8,778	.....	714,917	8,741	Ferro-alloys.
1916...	2,236	2,757	28,670	1,614	12,811	.....	417,899	6,233	
1917...	1,832	3,975	39,298	1,810	4,435	.....	302,739	6,295	4,147
1918...	4,562	2,783	50,034	2,856	3,488	.....	95,887	9,007	5,547

Year.	Molybdenite.	Nickel.		Pyrite, Iron and Copper.	Rutile.	Silver.		Zinc Ore. (c)
		Ore.	Metal.			Ore and Native Silver.	Metal. *Kg.*	
1906.....	1,026	6,081	77	197,886	55	1,565	6,370	3,308
1907.....	30	5,781	81	236,038	55	1,756	6,700	400
1908.....	35	5,190	81	269,129	83	2,262	7,470	2,435
1909.....	30	5,770	62	282,606	.....	2,729	7,780	983
1910.....	.....	19,639	69.8	329,642	116	.....	.....	2,219
1911.....	.....	27,743	172	369,055	76	2,892	7,635	2,240
1912.....	21	30,697	390	464,326	100	4,027	8,400	40
1913.....	12	49,990	690	441,291	77	5,411	9,400	897
1914.....	(d)83	48,529	794	414,886	30	7,372	12,904	243
1915.....	(d)97	77,018	892	513,335	170	8,431	11,900	1,829
1916.....	(d)137	79,903	808	295,354	103	7,515	9,000	1,017
1917.....	(d)248	69,639	379	328,694	129	7,147	9,100	269
1918.....	228	24,150	33	338,849	2,412	8,599	9,700	268

(a) *Tabeller vedkommende Norges Bergverksdrift*, and *Statistisk Aarbok for Kongeriket Norge*
(b) Exports, which represent production. (c) Includes lead ore. (d) Includes wolframite.

MINERAL IMPORTS OF NORWAY (a)

(In metric tons)

Year.	Borax. *Kg.*	Cement and Hydraulic Lime.	Coke, Coal, and Cinders. *Hectoliters.*	Copper and Brass.		Iron and Steel.	
				Plates and Bars.	Wares.	Pig.	Bars, Hoops, etc. Wrought Iron.
1907	79,810	16,647	24,274,260	(*b*) 954	1,107	23,345	32,764
1908	87,255	44,991	(*c*)2,073,907	(*b*)1,013	1,157	26,106	31,849
1909	79,786	57,768	(*c*)2,095,611	(*b*) 869	1,095	23,167	31,215
1910	105,453	20,100	(*c*)2,159,717	(*b*)1,118	1,406	28,034	34,623
1911	100,493	17,892	(*c*)2,187,246	(*b*)1,229	1,780	26,569	36,172
1912	103,923	27,960	(*c*)2,474,253	(*b*)1,567	2,116	29,908	44,756
1913	107,633	31,989	(*c*)2,482,424	(*b*)1,769	2,035	30,682	49,442
1914	85,185	42,967	(*c*)2,764,061	(*b*)3,441	2,337	32,254	44,951
1915	682,298	27,347	(*c*)3,095,049	(*b*)2,750	2,750	39,670	64,863
1916	644,723	87,438	(*c*)2,833,063	(*b*)1,374	2,148	34,712	60,239
1917	.....	.....	.....	.....	.....	.....	.....
1918	.....	23,091	(*c*)1,573,821	(*b*) 739	1,322	16,025	41,166
1919	.....	23,555	(*c*)1,739,970	(*b*)1,928	5,997	14,849	31,411

Year.	Iron and Steel *Continued.*						Lead in Pigs and Sheets.
	Anchors, Cables, and Chains.	Rails.	Nails, Spikes, and Screws.	Steel.	Sheets and Plates.	Other Manufactures.	
1907	2,653	6,989	991	1,592	47,758	48,965	887
1908	2,535	12,180	1,032	1,628	49,569	52,594	529
1909	1,750	9,051	1,049	1,911	46,195	55,198	536
1910	2,131	5,512	852	3,203	56,898	60,282	838
1911	2,327	15,312	1,129	3,908	65,847	72,170	939
1912	2,591	12,276	1,313	4,239	84,525	86,552	1,142
1913	2,479	15,291	1,613	3,197	76,158	86,411	1,054
1914	2,651	21,834	1,340	2,638	75,145	91,496	1,079
1915	2,260	32,345	1,644	1,645	112,694	111,546	1,482
1916	3,198	17,601	3,074	2,249	84,622	97,097	1,517
1917	.....	.....	.....	.....	.....	.....	.....
1918	2,481	16,119	2,502	2,177	25,365	54,390	730
1919	9,016	23,781	3,332	1,488	58,885	59,914	1,254

Year.	Lead-white and Zinc Oxide.	Petroleum and Paraffin.	Potash.	Salt.	Saltpeter.	Soda.	Sulphur. (*b*)	Tin in Blocks, etc.	Zinc in Bars, Plates, etc.
1907	1,245	44,231	588	163,458	1,004	5,819	11,412	332	3,549
1908	1,201	64,680	504	177,349	935	7,850	12,281	323	1,418
1909	1,304	63,042	475	164,195	572	8,357	10,293	280	1,336
1910	1,277	63,976	536	182,288	546	9,270	10,279	358	5,891
1911	1,465	71,496	524	192,354	786	9,566	8,782	353	9,173
1912	1,864	80,023	541	214,817	418	15,877	13,911	439	9,636
1913	2,502	79,253	572	214,987	522	16,255	15,411	333	13,560
1914	2,293	87,268	942	204,036	141	20,325	10,347	662	17,492
1915	2,478	55,945	1,111	263,507	31	23,798	6,804	1,029	31,811
1916	2,434	103,902	1,463	316,166	9	25,860	7,262	741	28,891
1917	.....	.....	.....	.....	.....	.....	.....	.....	.....
1918	419	44,395	54	310,597	7	21,315	3,036	55	393
1919	1,792	116,207	1,075	173,931	8	14,202	54	352	31,483

MINERAL EXPORTS OF NORWAY (a)
(In metric tons)

Year.	Apatite.	Copper.			Feldspar.	Iodine. *Kg.*	Iron Ore.
		Ore.	Ingot.	Scrap.			
1906.....	3,482	84	875	964	19,669	13,248	81,398
1907.....	1,830	1,581	1,033	1,644	29,399	13,780	132,593
1908.....	1,771	156	1,260	385	29,896	11,097	110,425
1909.....	1,365	3,245	1,335	543	33,692	13,620	38,933
1910.....	703	241	1,377	583	39,507	13,114	88,715
1911.....	500	924	1,091	575	34,864	16,982	180,932
1912.....	.....	423	1,551	366	39,844	11,642	404,990
1913.....	.....	74	2,644	167	40,843	12,149	568,763
1914.....	.....	0.1	2,558	502	27,966	3,096	467,796
1915.....	.....	438	2,691	293	12,607	576	425,892
1916.....	.....	2,175	1,430	359	9,570	1,131	404,700
1917.....	.....	.....	.....	.....	.....	.....	.....
1918.....	.....	725	1,254	4	1,026	5,373	96,696
1919.....	1,300	.....	394	30	3,059	3,042	33,247

Year.	Iron				Nickel Ore.	Pyrite.	Zinc.
	Pig and Scrap.	Bars and Hoops.	Nails and Spikes.	Steel.			
1906.....	7,362	8	6,786	21	*Nil.*	164,119	.....
1907.....	4,652	7	5,879	31	11	187,983	.....
1908.....	6,787	2	4,839	17	*Nil.*	218,851	.....
1909.....	11,429	24	5,187	11	3	216,767	.....
1910.....	13,455	5	6,878	34	.....	343,073	.....
1911.....	12,569	40	5,692	271	(*g*)385	343,850	.....
1912.....	16,889	.....	5,326	296	(*g*)594	424,121	.....
1913.....	26,917	.....	3,972	150	.....	460,912	10,538
1914.....	14,586	17	4,012	1,416	(*g*)696	403,255	16,517
1915.....	12,961	.....	6,021	2,005	(*g*)761	513,901	22,617
1916.....	21,355	.....	4,697	1,211	723	253,361	28,150
1917.....	.....	.....	.....	.....	.....	.....	.....
1918.....	3,411	.....	.....	.....	.....	240,774	3,380
1919.....	15,310	.....	.....	.....	.....	118,588	3,950

(a) From *Tabeller vedkommende Norges Bergvaerksdrift* and *Tabeller vedkommende Norges Handel.* (b) Includes flowers of sulphur. (c) Returns not available. (d) Includes a small quantity of fluorspar (e) In metric tons. (f) Includes a quantity of sheet aluminium. (g) Metallic nickel.

PORTUGAL

The subjoined table reports the mineral production of Portugal:

MINERAL PRODUCTION OF PORTUGAL (a)

(In metric tons)

Year.	Antimony Ore.	Arsenic Ore.	Coal (Anthracite). (c)	Copper.			
				Copper-Iron Pyrite. (c)	Other Ores.	Cement.	Matte.
1901	(b)	527	16,000	443,397	(b)	2,061	(b)
1902	68	736	11,000	413,714	655	2,205	(b)
1903	83	698	8,063	376,177	527	2,448	(b)
1904	31	1,370	12,805	383,581	297	(b)	(b)
1905	84	1,562	11,449	352,479	210	2,148	(b)
1906	481	1,322	6,762	350,746	196	3,634	(b)
1907	383	1,538	8,824	241,771	2,478	2,942	298
1908	76	1,655	4,614	81,417	15,455	3,041	564
1909	6	1,420	6,274	12,337	1,321	3,037	309
1910	25	974	8,149	19,161	230	3,768	230
1911	.....	887	10,610	15,287	517	3,979	283
1912	100	1,006	15,626	120,148	1,309	4,028	.....
1913	19	925	25,037	13,550	.....	4,177	.....
1914	*Nil.*	960	29,680	40,850	219,140	3,200	.....

Year.	Gold. *Kg.*	Iron Ore.	Lead Ore (Galena).	Manganese Ore.	Sulphur Ore.	Tin Ore and Metal.	Tungsten Ore.
1901	2.0	21,599	445	904	(c)	31	90
1902	2.0	19,914	1,651	(b)	(c)	24	234
1903	1.3	15,200	830	30	(c)	(b)	228
1904	*Nil.*	12,488	291	(b)	(c)	51	290
1905	*Nil.*	3,200	50	(b)	(c)	20	358
1906	*Nil.*	(b)	511	22	(c)	22	570
1907	10.5	(b)	510	1,374	123,393	35	226
1908	57.0	(b)	481	(b)	24,522	28	106
1909	25.0	(b)	736	(b)	272,398	18	673
1910	4.1	3,360	919	(b)	293,745	9	948
1911	3.6	19,541	1,185	6	267,486	86	903
1912	3.5	35,210	495	6	481,295	173	1,227
1913	1.0	49,182	1,046	(b)	377,533	254	1,039
1914	*Nil.*	6,639	2,163	(b)	32,554	370	615

(a) From reports specially furnished *The Mineral Industry* by the Chief of the Department of Mi
of the Ministerio das Obras Publicas, except for 1904 to 1906, inclusive, and 1913 and 1914, whi
are from official Government reports. The mineral production of the country is identical with e
ports, except in the case of coal. (b) Not reported. (c) Consumed in the country. (c) Previo
to 1907 the figures for "Sulphur Ore" (largely pyrite) were included under "Copper-Iron Pyrite."

RUSSIA

The mineral and metallurgical production of Russia, according to the best statistics available to MINERAL INDUSTRY, is given in the subjoined tables.

MINERAL AND METALLURGICAL PRODUCTION OF RUSSIA (*a*)

(In metric tons; 1 metric ton = 61.05 poods)

Year.	Asbestos.	Chrome Ore.	Coal.	Copper.	Gold. (*b*)	Pig Iron.	Lead.	Manganese Ore.
1901..	4,398	22,169	16,526,652	8,467	$22,763,967	2,866,779	156.0	522,395
1902..	4,508	19,656	16,465,852	8,817	22,258,343	2,598,086	225.3	536,519
1903..	5,264	16,421	17,868,515	9,232	24,147,222	2,487,783	106.3	414,334
1904..	7,502	26,575	19,608,631	9,835	24,627,537	2,972,115	90.3	430,090
1905..	5,896	27,051	18,727,766	8,515	20,521,587	2,628,101	700.2	508,635
1906..	9,197	16,969	21,593,158	9,296	20,020,862	2,694,895	906.8	1,015,686
1907..	9,398	(*g*) 26,357	25,741,321	15,930	26,518,253	3,041,570	520.0	(*g*) 1,003,528
1908..	10,911	(*g*) 10,950	(*g*) 25,903,560	17,118	33,143,810	2,818,450	522.5	362,303
1909..	(*h*) 13,129	22,213	24,532,349	19,656	31,889,956	2,889,353	.....	574,938
1910..	(*h*) 10,936	1,362	(*f*) 23,105,628	(*f*) 22,619	(*f*) 35,566,045	(*f*) 3,042,046	.....	668,050
1911..	17,071	1,238	28,007,239	(*f*) 25,097	(*f*) 34,550,609	3,593,000	.....	(*i*) 636,180
1912..	18,138	21,277	30,641,163	33,513	28,852,881	3,726,000	.....	903,226
1913..	18,594	.....	32,206,000	34,282	22,199,000	3,801,273	.....	1,130,000
1914..	.....	.....	.....	32,250	24,300,000	.....	.....	652,354
1915..	.....	.....	.....	35,470	.....	**3,792,516**	.....	.....
1916..	.....	.....	.....	.....	.....	3,861,600	.....	.....

Year.	Petroleum.	Phosphate Rock.	Platinum. *Kg.*	Pyrite.	Quicksilver.	Salt.	Silver *Kg.*	Sulphur.	Zinc.
1900..	9,844,390	25,663	5,089	23,154	141	1,968,007	2,293	1,587	5,963
1901..	10,925,471	21,276	6,371	30,732	363	1,705,924	1,088	2,489	6,104
1902..	10,445,536	13,709	6,135	26,465	416	1,847,021	1,200	1,800	8,264
1903..	9,759,214	14,635	6,009	22,780	362	1,658,938	1,152	281	9,894
1904..	10,058,968	20,282	5,016	31,667	332	1,908,275	726	16	10,612
1905..	7,505,637	20,585	5,250	30,689	318	1,844,678	2,965	16	7,911
1906..	8,167,934	18,970	5,776	20,660	210	1,730,934	430	39	9,602
1907..	9,098,931	(*g*) 15,457	5,903	18,316	(*g*) 132	1,873,171	7,843	(*d*) 57	10,409
1908..	8,732,301	(*g*) 14,976	4,883	56,345	147	1,879,717	9,595	(*d*) 85	9,960
1909..	8,961,507	(*h*) 21,326	5,120	(*f*) 46,078	.....	2,259,690	(*h*) 15,415	.....	7,644
1910..	8,952,793	(*h*) 24,883	5,471	(*f*) 55,980	.....	2,047,980	(*h*) 14,841	.....	(*f*) 8,631
1911..	9,152,315	(*h*) 25,503	(*f*) 5,432	113,054	.....	2,013,765	15,512	.....	(*f*) 9,652
1912..	9,249,600	.....	5,523	123,990	.....	.....	.....	.....	8,763
1913..	9,474,876	.....	4,897	.....	.....	.....	.....	.....	7,610
1914..	9,099,494	.....	4,880	.....	.....	.....	.....	.....	.....
1915..	.....	.....	3,374	.....	.....	.....	.....	.....	.....

(*a*) From official sources. (*b*) The value of gold is taken at $20.67 per ounce. (*d*) Includes sulphide ore. (*f*) Statistics of Association of Russian Manufacturers and Traders. (*g*) St. Petersburg Scientific Committee. (*h*) The Russian Year Book, Dr. Kennard, London. (*i*) Exports. (*j*) *Mineral Resources of U. S.*

SOUTH AMERICA

The following tables itemize the statistics of the production and the foreign commerce, or both, of mineral and metallurgical products of South American countries so far as available. No statistics later than those given in the tables have been published. Figures in full-faced type are either provisional figures or estimates.

MINERAL AND METAL PRODUCTION OF BOLIVIA (a)

(In metric tons)

Year.	Antimony Ore.	Bismuth.		Copper Ore.	Copper. (c)	Gold. (b)	Silver. (d)	Tin Ore.	Tungsten Ore.
		Metal.	Ore.						
1909	.....	89	236.762	.....	3,097	.....	155.4	35,566	170
1910	.....	97	311.060	.....	3,212	.....	143	38,548	207
1911	312	(g)415	1,208.689	.....	2,950	$ 22,313	128.0	37,073	297
1912	91	(g)478	.....	.....	4,707	23,038	123.9	38,614	472
1913	62	391	32	.....	4,020	**175,000**	81.3	44,597	283
1914	186	(g)437	.....	4,793	3,874	.....	72	37,259	276
1915	17,923	(g)663	.....	17,945	5,839	.....	78	36,324	755
1916	27,414	(g)680	.....	23,860	5,151	.....	.....	35,543	3,035
1917	23,370	255	279	32,135	5,310	.....	14,657	46,430	3,891
1918(f)	6,849	145	116	26,000	2,341	.....	57	48,800	3,418
1919(f)	238	(g)374	.....	22,970	.....	.....	.....	48,500	1,995

(a) From a British Consular report and Revista de Aduanas. (b) Reduced to U. S. currency. (c) Includes ingots, precipitate, matte and concentrate. (d) Includes ingots, ore, and sulphide. (f) Exports. (g) Metal and metal content of ore.

MINERAL EXPORTS OF BRAZIL (a)

(In metric tons or dollars) (d)

Year.	Agate.	Carbonado. *Carats*	Copper Ore.	Diamonds. *Carats.*	Gold.	Manganese Ore.	Mica	Monazite.	Platinum	Precious Stones. (b)	Rock Crystal.
1909(e)	.....	177,572	(c)	58,862	$2,252,900	240,774	.....	6,462	*Nil*	$56,338	.....
1910(e)	34	13,848	(c)	14,366	1,954,674	253,953	1.4	5,437	*Nil*	745	.....
1911(e)	112	63,400	1	103,567	2,850,370	173,941	9.0	371	*Nil*	135,220	24
1912(e)	103	47,998	.....	139,175	2,676,950	154,870	11.5	3,398	*Nil*	74,597	45
1913	.....	.....	.....	.....	2,692,154	122,300	.....	1,437	*Nil*	174,066	.....
1914	.....	.....	.....	.....	2,127,515	183,600	15.3	600	*Nil*	21,022	.....
1915(e)	.....	$119,994	.....	11,803	2,390,719	288,671	11.9	439	*Nil*	44,024	*Nil*
1916(e)	.....	457,941	.....	84,004	.....	503,130	53.7	375	$4,003	116,784	1
1917	.....	.....	.....	.....	.....	532,855	.....	.....	.....	.....	.....

(a) As reported by the *Brazilian Review*. (b) Other than carbonado and diamonds. (c) Statistics not available. (e) Reported by U. S. Consul at Rio de Janeiro.

MINERAL PRODUCTION OF CHILE (a)
(In metric tons)

Year.	Borax.	Coal.	Iron Ore.	Copper.	Gold. *Kg.*	Guano.	Iodine.	Salt.	Silver. *Kg.*	Sodium Nitrate.	Sulphur.
1903..	16,879	827,112	.....	29,923	994	11,134	387	16,264	28,552	1,444,920	3,560
1904..	16,733	751,628	.....	31,025	1,135	2,669	461	17,674	28,501	1,487,598	3,594
1905..	19,612	793,927	.....	29,126	1,055	19,380	564	12,108	16,315	1,669,806	3,470
1906..	28,996	932,488	.....	25,829	1,135	4,709	331	17,116	12,211	1,822,144	4,598
1907..	28,374	832,612	.....	28,863	1,907	7,518	4,202	18,982	18,736	1,846,036	2,905
1908..	35,039	939,836	.....	42,097	1,189	871	330	16,257	43,569	1,970,974	2,705
1909..	32,218	898,971	.....	42,726	1,268	10,692	474	20,463	35,907	2,110,961	4,508
1910..	35,192	1,074,174	.....	38,232	1,088	12,683	581	23,361	34,958	2,465,415	3,823
1911..	45,558	1,188,053	.....	36,420	437	17,841	437	23,720	27,675	2,521,023	4,451
1912..	43,356	1,334,407	.....	41,647	1,101	18,266	458	17,045	30,178	2,585,850	4,431
1913(c)	**50,225**	**1,283,450**	**14,100**	42,264	**1,147**	.....	**437**	.....	39,564	2,666,835	**6,647**
1914(c)	34,203	266,962	63,505	45,682	**1,017**	.....	489	.....	**36,581**	1,846,783	**10,008**
1915(c)	.....	.....	.....	52,081	.....	.....	.....	.....	.....	2,023,562	.....
1916(c)	.....	.....	.....	71,430	.....	.....	.....	.....	.....	.....	.....

(a) From *Estadistica Minera de Chile.* (b) The combined output of the years 1894 to 1902, inclusive was 86,802 tons.. (c) The combined output of Chile up to the end of 1902 is estimated at 20,650,000 tons. (c) Exports. (f) The combined output of Chile up to the end of 1902 is estimated at 163,704 tons, valued at 5,041.560 pesos ($1,840,169).

MINERAL AND METAL PRODUCTION OF PERU (a)
(In metric tons)

Year.	Bismuth.	Borate.	Coal. (b)	Copper.	Gold. *Kg.*	Lead.	Petroleum.	Quicksilver. *Kg.*	Silver. *Kg.*	Salt.	Tungsten Ore.	Vanadium Ore.
1911...	24	1,923	324,000	27,735	741.2	2,208	195,276	560	289,383	24,867	48	.....
1912...	51	1,674	278,927	26,970	1,435.0	4,050	233,600	400	324,352	23,292	195	.....
1913...	25	2,001	273,945	27,776	1,435.0	3,927	276,147	460	299,132	24,433	290	.....
1914...	11	1,263	283,860	27,090	1,500.0	3,048	252,666	700	286,600	25,933	196	14
1915...	.....	510	290,743	34,727	1,690.0	2,696	363,162	920	294,425	25,729	375	3,145
1916...	.....	1,289	319,063	43,078	1,907.0	2,038	345,758	2,101	335,529	26,069	523	3,448
1917...	1	800	353,595	45,176	1,887.0	1,272	347,092	1,500	337,928	27,073	406	4,083
1918...	.....	523	346,226	44,414	1,793.0	632	335,002	1,500	304,253	26,663	243	2,183
1919...	.....	519	344,260	39,230	2,029.0	1,066	348,831	.....	305,497	27,724	129	2,947

(a) Reported by the Cuerpo de Ingenieros de Minas del Peru, in its *Boletin.* (b) Includes asphaltum and bituminous schist.

SPAIN

The following tables record the mineral and metal production of Spain as reported by official authorities:

MINERAL PRODUCTION OF SPAIN (*a*)
(In metric tons)

Year.	Aluminous Earths.	Antimony Ore.	Arsenic.	Asphaltum. (Refined)	Asphalt, Rock. (*d*)	Barytes.	Bismuth Ore.	Cement, Hydraulic.	Coal.	
									Anthracite.	Bituminous.
1906..	386	180	1,114	6,229	7,794	330	.....	299,294	113,747	3,095,043
1907..	1,209	205	1,500	8,643	8,219	314	.....	329,926	164,498	3,531,337
1908..	60	124	2,004	9,231	12,373	334	.....	343,001	188,463	3,696,653
1909..	35	(*b*)	506	6,582	5,284	422	78	472,909	198,302	3,662,573
1910..	440	15	444	8,478	(*b*)	476	53	484,161	211,958	3,600,056
1911..	461	100	331	3,495	(*b*)	635	52	486,085	209,227	3,454,394
1912..	508	500	(*b*)	6,087	(*b*)	1,096	73	525,319	226,663	3,625,666
1913..	388	(*b*)	(*b*)	5,695	(*b*)	3,049	56	511,961	232,517	3,783,214
1914..	249	(*b*)	(*b*)	4,148	5,765	2,474	40	473,764	228,302	3,905,080
1915..	314	300	(*b*)	2,671	4,521	4,218	17	476,255	222,621	4,135,919
1916..	256	515	(*b*)	2,591	7,316	10,508	11	536,246	268,093	4,847,475
1917..	470	502	(*b*)	1,950	(*b*)	10,147	14	462,357	324,756	5,042,213
1918..	286	80	104	2,367	8,395	4,170	34	401,117	377,216	6,134,986
1919..	227	.....	42	2,385	10,091	11,459	75	363,460	398,771	5,304,866

Year.	Coal (*Continued*).		Coke.	Copper Ore. (*c*)	Copper.				Fire Clay.	Fluorspar.	Graphite.
	Lignitic	Briquets.			Blister.	Matte.	Precipitate.	Sulphate.			
1906.....	189,048	311,328	435,808	2,888,778	(*b*)	9,068	19,200	.....	.....	70	.....
1907.....	191,001	355,718	476,360	3, 82,645	(*b*)	9 886	20,887	.....	.....	270	.....
1908.....	223,160	296,216	477,059	2,985,779	(*b*)	205	19,599	.....	.....	253	.....
1909.....	265,019	(*b*)	500,909	2,955,254	15,442	2,077	16,641	.....	150	246	.....
1910.....	245,518	474,891	521,078	3,231,418	14,703	2,684	14,056	.....	159	180	.....
1911.....	252,051	478,143	516,342	3,284,184	16,385	1,910	12,353	.....	613	499	.....
1912.....	283,480	465,106	489,558	3,364,294	20,638	1,861	15,044	.....	6,468	265	.....
1913.....	276,791	486,228	595,677	2,268,691	20,839	3,049	7,260	.....	6,250	351	.....
1914.....	291,057	558,329	597,315	1,502,599	(*f*)13,335	.....	10,371	532	986	79	.....
1915.....	328,213	555,357	623,353	1,480,412	20,324	2,001	12,374	1,126	5,570	370	30
1916.....	473,106	555,975	759,754	1,773,922	(*f*)20,769	.....	12,111	7,600	6,302	277	1,240
1917.....	637,841	449,447	542,767	1,901,341	(*f*)25,557	.....	12,969	10,414	4,245	250	1,980
1918.....	726,348	409,728	630,210	1,007,708	20,063	1,600	23,441	8,603	1,215	350	710
1919.....	539,872	.....	331,000	1,470,091	23,419	.....	.....	7,988	.....	280	1,958

Year.	Iron Ore.		Iron and Steel.			Kaolin (China Clay).	Lead (Argentiferous).	
	Argentiferous.	Non-argentiferous.	Pig.	Wrought Iron.	Iron and Steel, Worked.		Ore.	Metal.
1906...	126,445	9,448,533	315,309	6,035	274,280	610	158,425	53,856
1907...	(*b*)	9,896,178	355,240	14,767	310,125	640	165,289	51,430
1908...	(*b*)	9,271,592	403,554	21,807	262,843	1,370	165,382	53,741
1909...	3,813	8,786,021	428,622	24,187	242,596	570	161,496	43,552
1910...	46,161	8,666,795	373,322	59,133	260,931	1,496	150,592	38,548
1911...	(*b*)	8,773,691	408,667	11,166	286,260	4,469	156,569	40,379
1912...	1,588	9,133,007	403,243	(*h*)	297,366	4,920	93,850	49,212
1913...	(*b*)	9,861,668	.....	(*h*)	(*g*)666,769	5,263	23,600	(*i*)
1914...	(*b*)	6,819,964	(*h*)	(*h*)	(*g*)382,044	4,870	22,373	(*i*)
1915...	(*b*)	5,617,839	(*h*)	(*h*)	(*g*)387,314	4,700	2,935	(*i*)
1916...	(*b*)	5,856,861	497,726	(*h*)	322,931	1,500	7,371	(*i*)
1917...	(*b*)	5,551,071	357,699	(*h*)	470,242	1,220	13,218	(*i*)
1918...	.....	4,692,651	386,550	(*h*)	303,206	2,000	3,505	(*i*)
1919...	.....	4,640,061	294,167	(*h*)	241,189	34	41,875	24,177

Year.	Lead (Non-argentiferous).		Magnesite.	Manganese Ore.	Mineral Paints (Ocher).	Phosphate Rock.	Pyrite (Iron).	Pyrite (Arsenical).	Quicksilver.	
	Ore.	Metal.							Ore.	Metal.
1906....	105,095	131,614	.....	62,822	164	1,300	189,243	2,434	28,965	1,568
1907....	103,632	135,066	.....	41,504	114	3,547	225,830	3,423	28,789	1,212
1908....	126,667	134,321	.....	16,745	400	4,483	263,451	5,533	42,210	1,068
1909....	137,050	136,441	850	7,827	418	1,387	258,931	3,235	37,398	1,393
1910....	216,738	151,975	1,277	8,607	759	2,840	294,184	1,461	22,714	1,114
1911....	165,843	149,540	1,400	5,607	622	3,520	344,879	1,056	19,940	1,494
1912....	190,162	183,400	1,480	17,400	600	3,292	421,070	(b)	21,898	1,256
1913....	279,078	(j)198,829	958	21,594	600	3,548	926,913	(b)	19,960	1,246
1914....	246,221	(j)143,524	583	8,965	1,500	8,312	984,885	(b)	17,714	953
1915....	285,266	(j)171,472	1,400	14,328	1,500	9,080	802,383	(b)	20,717	1,222
1916....	260 283	(j)147,407	2,500	14,178	800	14,111	953,679	(b)	19,799	795
1917....	240,368	(j)172,909	800	57,474	780	28,148	976,918	(b)	18,705	827
1918....	216,133	(j)169,709	1,700	77,714	700	43,303	590,008	250	17,537	567
1919....	136,180	101,544	120	66,585	680	25,035	431,189	150	24,966	1,226

Year.	Salt.	Silver.		Soapstone.	Sodium Sulphate.	Sulphur.		Tin Ore, Dressed.	Topas, Kg.	Tungsten Ore.	Zinc.		
		Ore.	Metal. Kg.			Crude Rock.	Refined.				Ore.	Spelter.	Sheets.
1906.....	541,978	470	126,424	3,609	.....	28,965	700	86	171	430	170,384	6,209	2,639
1907.....	605,895	702	127,435	13,875	.....	27,054	3,612	315	266	386	191,853	6,144	2,485
1908.....	822,677	441	129,881	4,730	.....	13,872	2,988	838	(b)	226	156,233	6,357	2,693
1909.....	823,747	388	143,403	5,583	141	21,750	3,429	( )1,555	(b)	129	163,522	2,526	6,102
1910.....	678,057	217	129,157	4,665	410	30,113	3,834	35	149	153	156,113	2,722	7,017
1911.....	679,947	858	110,082	5,647	411	40,662	6,580	34	(b)	96	162,140	3,429	2,904
1912.....	650,047	668	143,439	4,635	570	42,344	4,592	5,079	(b)	169	175,311	3,076	4,067
1913.....	610,429	405	125,394	4,407	293	62,653	7,499	6,616	(b)	235	117,831	2,691	3,312
1914.....	927,767	496	134,515	4,612	363	47,180	8,060	877	(b)	437	114,317	2,963	8,780
1915.....	793,340	210	142,003	963	191	28,937	9,670	102	(b)	511	81,922	8,117	
1916.....	895,928	275	140,521	3,561	1,900	46,923	10,629	86	(b)	455	166,053	8,523	
1917.....	781,106	96	114,342	3,450	875	84,979	12,885	77	(b)	546	123,845	10,155	
1918.....	320,531	962	98,988	3,328	3,697	72,360	12,738	71	(b)	4,555	106,958	15,900	
1919.....	481,921	77	83,000	3,024	5,613	89,586	11,445	154	(b)	337	103,608	16,314	

(a) Figures are from *Estadistica Minera de España*. (b) Not reported. (c) Includes copper pyrite. (d) Includes bituminous rock and crude asphalt. (e) Undressed tin ore. (f) Includes copper matte. (g) Includes pig iron. (h) Included in Iron and Steel, Worked. (i) Not reported separately; included with non-argentiferous lead. (j) Includes argentiferous lead.

SWEDEN

The official statistics of mineral production, imports and exports, are summarized in the following tables:

MINERAL PRODUCTION OF SWEDEN (a)
(In metric tons)

Year.	Alum.	Coal.	Copper.			Feldspar.	Graphite.	Gold. Kg.
			Ore.	Ingot.	Sulphate.			
1907.....	131	305,338	21,957	1,577	782	20,244	33	28.1
1908.....	138	305,206	21,371	2,808	731	17,494	66	20.3
1909.....	132	246,808	9,562	2,375	628	15,772	26	14.1
1910.....	182	302,786	3,638	3,111	20	21,591	49	1.8
1911.....	159	311,809	1,623	3,221	320	36,235	65	11.0
1912.....	145	360,291	3,059	3,957	870	34,305	79	30.6
1913.....	159	363,965	5,458	4,315	428	37,878	88	25.4
1914.....	.....	366,639	8,839	4,692	651	20,818	56	84.3
1915.....	.....	412,261	10,549	4,561	.....	12,105	87	37.3
1916.....	.....	414,825	13,895	3,181	1,268	12,724	194	18.2
1917.....	.....	442,633	13,579	4,423	956	18,533	123	11.1
1918.....	.....	404,494	21,408	2,956	.....	17,850	.....	15.0
1919.....	.....	429,267	7,279	3,558	.....	12,905	.....	21.6

Year	Iron and Steel.					Steel.		
	Ore.	Pig.	Blooms, Unwelded	Bars, Rods, etc.	Iron Sulphate.	Bessemer.	Martin.	Crucible and Electro.
1907....	4,478,917	615,778	174,405	417,535	159	77,036	341,893	1,287
1908....	4,712,494	567,821	152,256	390,957	277	81,054	355,394	1,169
1909....	3,885,046	444,764	120,669	308,823	182	63,351	248,757	1,518
1910....	5,549,987	603,939	151,713	431,722	236	97,583	372,451	2,215
1911....	6,150,718	634,392	146,722	423,170	156	93,853	372 705	4,309
1912....	6,699,226	699,816	148,828	470,352	335	107,254	307,637	3,941
1913....	7,475,571	730,257	158,472	516,561	320	115,839	404,118	5,661
1914....	6,586,630	639,718	116,074	441,060	158	93,210	469,387	4,594
1915....	6,883,308	760,701	119,629	537,922	.....	91,070	503,766	5,582
1916....	6,986,298	732,734	119,197	526,353	279	75,800	525,500	9,388
1917....	6,217,172	828,969	114,429	487,587	146	77,854	491,257	11,889
1918....	6,623,661	761,822	92,823	426,473	.....	66,155	465,016	14,431
1919....	4,981,110	493,701	63,629	381,541	.....	57,593	420,547	13,148

Year.	Lead.	Manganese Ore.	Pyrite.	Silver-Lead Ore.	Silver. Kg.	Nickel Ore.	Zinc Ore.
1907.....	813	4,334	27,113	1,987	929	.....	50,884
1908.....	277	4,616	29,569	2,058	630	.....	40,077
1909.....	166	5,212	16,104	1,721	512	.....	43,760
1910.....	355	5,752	25,445	2,700	30	.....	49,453
1911.....	1,134	5,377	30,096	2,999	1,289	.....	51,242
1912.....	1,073	5,101	31,835	2,877	962	.....	50,036
1913.....	1,235	4,001	34,319	3,222	1,037	.....	50,752
1914.....	1,396	3,643	33,312	3,110	1,074	156	42,279
1915.....	1,918	7,607	76,324	2,671	754	1,642	55,937
1916.....	2,076	8,894	97,848	3,707	1,180	3,561	60,700
1917.....	3,174	19,873	142,660	3,709	1,784	4,991	51,312
1918.....	2,241	16,570	141,181	3,170	980	2,480	48,507
1919.....	827	12,278	108,770	1,671	620	416	49,451

(a) From *Sveriges Officiella Statistik Bergshanteringen.*

MINERAL IMPORTS OF SWEDEN (a)
(In metric tons or dollars; 1 krona = 27 cents)

Year.	Asbestos. (c)	Asphalt.	Barytes.	Borax.	Boric Acid.	Bromine and Bromides. *Kg.*	Cement.	Chalk, White, Unground. *Hectoliters.*	Coal.
1906....	287	7,134	559	321	79	9,908	13,136	10,777	3,718,884
1907....	672	8,213	610	490	85	6,784	17,801	(g) 860	4,146,785
1908....	505	6,368	514	347	71	11,499	6,158	(g) 419	4,427 507
1909....	383	7,922	529	365	76	10,280	12,944	(g) 512	4,084,055
1910....	671	7,406	625	379	92	10,913	15,438	(g) 473	4,180,250
1911....	1,011	6,803	607	381	76	16,819	24,830	(g) 605	3,964,870
1912....	635	7,645	644	434	100	9,319	17,438	(g) 422	4,293,719
1913....	1,094	6,809	610	470	120	11,211	12,120	(g) 2,337	4,878,854
1914....	789	7,348	730	462	127	21,064	14,769	(g) 2,332	4,626,932
1915....	895	10,567	1,665	825	211	14,904	15,579	(g) 4,769	3,836,097
1916....	896	6,331	3,308	499	72	17,792	15,685	(g) 732	4,027,141
1917....	70	4,287	.....	176	47	8,652	5,221	.....	1,500,425
1918....	265	4,716	.....	.....	.....	.....	5,810	.....	1,926,711
1919....	.....	.....	.....	.....	.....	.....	4,398	.....	1,928,962
1920....	.....	.....	.....	.....	.....	.....	4,592	.....	2,806,303

Year.	Copper, also Alloys of Copper.	Emery.	Graphite.	Gypsum.	Pig Iron and Scrap.	Lead. (c)	Litharge.	Phosphorus. *Kg.*	Platinum. *Kg.* (c)
1906....	7,871	284	255	13,496	108,194	3,596	212	79,048	133
1907....	6,945	336	375	15,037	115,174	3,384	210	77,936	109
1908....	6,849	308	540	11,644	109,837	3,964	248	107,301	117
1909....	5,639	428	443	14,212	99,510	3,222	217	88,241	72
1910....	9,710	438	398	15,816	118,373	3,453	267	99,145	77
1911....	8,817	459	398	14,505	114,837	2,901	270	77,837	103
1912....	7,767	474	513	19,237	140,145	3,019	316	88,411	84
1913....	10,265	655	576	23,222	172,489	3,394	327	92,487	126
1914....	13,557	495	334	13,210	163,290	3,022	474	140,040	90
1915....	14,901	915	851	9,244	166,026	2,296	538	176,650	282
1916....	12,642	1,398	719	14,353	194,100	5,945	677	103,726	234
1917....	3,715	.....	668	9,427	82,615	135	.....	21,187	199
1918....	4,031	.....	.....	11,729	40,943	1,081	.....	54,430	76
1919....	14,639	.....	.....	.....	.....	2,653	.....	38,350	.....
1920....	18,178	.....	.....	.....	.....	4,039	.....	99,506	.....

Year.	Potassium.				Quicksilver. *Kg.*	Salt.		Silver.	
	Chloride.	Cyanide. *Kg.*	Hydrate.	Carbonate.		Crude.	Refined.	Bullion and Mfrs. *Kg.*	Specie.
1906.....	1,986	4,106	2,486	1,082	5,535	88,341	3,700	19,020	$93,990
1907.....	1,840	4,150	2,484	1,269	8,930	(h) 835,190	18,821	26,834	52,463
1908.....	2,190	3,563	2,835	1,209	7,299	(h) 903,633	24,394	20,149	94,368
1909.....	1,805	3,808	2,627	1,312	6,077	(h) 766,195	24,143	17,495	154,265
1910.....	2,335	4,272	2,767	1,346	7,079	(h) 766,512	22,425	21,162	75,604
1911.....	1,288	4,993	3,737	1,268	4,164	(h) 736,935	26,026	15,175	135,410
1912....	2,541	(d) 7,545	(e)3,262	1,380	5,110	(h)1,049,670	22,009	21,220	144,491
1913.....	2,081	(d) 7,607	(e)5,234	1,417	5,142	(h) 914,371	24,927	20,550	68,752
1914.....	2,640	(d) 4,634	(e)5,127	1,644	5,823	(h) 969,926	25,119	29,356	57,963
1915.....	3,407	(d)10,599	(e)5,779	1,596	13,714	(h) 990,857	20,568	40,689	391,857
1916.....	4,431	(d)13,105	(e)8,664	2,730	15,905	(h)1,435,202	28,026	41,407	.....
1917.....	1,845	(d)14,504	(e)1,439	1,778	16,604	(h)1,207,490	21,650	66,420	.....
1918.....	1,302	.....	(e) 807	410	.....	(h)1,115,935	22,993	19,371	.....
1919....	459	.....	(e)5,262	2,204	.....	383,544	14,325	25,131	.....
1920.....	6,058	.....	(e)5,375	1,909	.....	738,803	26,843	30,084	.....

Year.	Sodium.				Sulphur.	Sulphuric Acid.	Tin.		Zinc and Mfrs.
	Carbonate. (i)	Hydrate.	Nitrate.	Sulphate. (f)			Salts. Kg.	Block and Scrap.	
1907....	14,970	1,628	26,181	21,486	25,456	2,628	6,117	891	5,407
1908....	14,149	1,256	27,631	18,717	30,806	3,073	2,817	808	4,626
1909....	13,490	1,119	28,894	20,226	26,836	1,955	1,357	794	5,294
1910....	15,594	1,260	32,340	22,429	38,530	2,707	1,161	764	5,843
1911....	15,777	2,501	31,324	27,482	34,622	861	915	866	5,951
1912....	18,255	.....	35,107	26,540	38,471	593	(k)73,045	1,032	6,975
1913....	18,473	.....	33,891	31,740	39,715	1,114	(k)56,982	1,083	6,114
1914....	18,698	.....	41,657	32,401	36,054	455	(k)55,931	1,482	7,835
1915....	21,622	.....	30,913	42,615	26,431	36	(k)54,423	4,240	9,762
1916....	14,983	.....	36,360	57,571	26,884	1	(k)29,816	998	9,993
1917....	3,829	.....	17,178	46,298	14,618	.....	(k)17,253	308	7,075
1918....	2,415	.....	6,763	36,733	19,867	.....	.....	387	874
1919....	14,217	.....	23,212	13,475	22,297	.....	.....	998	10,635
1920....	18,783	.....	23,049	50,338	57,659	.....	.....	1,284	5,280

MINERAL EXPORTS OF SWEDEN (a)

(In metric tons or dollars; 1 krona = 27 cents)

Year.	Alum.	Ammonium Sulphate.	Antimony, Crude. Kg.	Asbestos, Kg. (c)	Cement.	Coal (Anthracite).	Copper.		Graphite.
							Ore.	Copper and Alloys.	
1905 ...	12	445	3,147	2,386	38,504	425	2,137	2,586	23
1906 ...	11	30	4,584	1,510	45,960	1,352	1,841	2,595	12
1907 ...	7	Nil.	4,485	5,608	18,053	2,925	882	1,933	8
1908 ...	9	202	4,188	1,412	34,164	1,293	1,114	2,493	18
1909 ...	5	331	6,536	1,093	33,197	771	723	2,152	7
1910 ...	11	704	4,555	1,242	73,351	776	878	2,580	7
1911 ...	2	253	7,320	760	108,653	1,045	1,114	2,500	12
1912 ...	15	42	9,151	564	127,142	4,952	1,577	4,273	9
1913 ...	6	254	6,803	1,066	137,074	1,443	1,709	3,495	48
1914 ...	18	90	12,752	1,743	39,347	326	1,352	8,039	133
1915 ...	143	5,583	31,680	2,424	61,116	5	3,346	4,210	165
1916 ...	120	1	36,695	.....	77,717	1	2,278	4,654	8
1917 ...	.....	.....	.....	29,161	4,651	3,741	.....	2,007	3
1918 ...	.....	.....	.....	7,515	6,236	1,705	.....	.....	.....
1919 ...	.....	.....	.....	.....	37,200	.....	.....	2,976	.....
1920 ...	.....	.....	.....	.....	68,131	.....	.....	1,781	.....

Year.	Gypsum and Mfrs.	Iron and Steel.		Lead. (c)	Peat.	Phosphorus. Kg.	Potassium Chlorate.
		Ore.	Pig-Iron and Scrap.				
1905.....	156	3,316,626	120,987	514	5,157	34,388	1,499
1906.....	6	3,661,218	126,283	532	6,531	700	857
1907.....	16	3,521,717	139,466	519	6,524	(b)	1,753
1908.....	37	3,654,268	112,522	496	5,559	400	1,364
1909.....	21	3,196,453	112,793	319	9,999	1,305	1,400
1910.....	41	4,413,600	143,522	557	9,754	265	1,383
1911.....	13	5,086,898	158,328	1,181	10,371	595	1,564
1912.....	2	5,520,653	213,619	1,003	7,276	600	1,653
1913.....	1	6,439,750	216,013	745	7,135	900	1,423
1914.....	48	4,787,314	181,784	414	8,981	19,025	1,591
1915.....	549	5,992,970	304,465	568	26,313	102,563	(l)1,312
1916.....	184	5,539,580	231,216	360	20,212	2,927	695
1917.....	265	5,613,148	231,669	465	3,973	.....	1,132
1918.....	393	4,485,500	180,116	155	2,414	4,000	648
1919.....	.....	2,418,989	81,263	130	.....	.....	871
1920.....	.....	3,736,329	115,417	284	.....	.....	2,785

Year.	Salt, Refined. *Kg.*	Silver Bullion. *Kg.*	Sodium Carbonate. (i)	Sulphur.	Tin.		Zinc.	
					Block and Scrap.	Mfrs. *Kg.*	Ore.	Crude and Mfrs.
1905....	*Nil.*	10	29	4	33.9	654	51,765	295
1906....	8,652	77	13	12	51.0	353	45,380	410
1907....	4,452	160	39	1	67.9	2,518	41,236	529
1908....	14,300	136	114	7	54.0	274	38,543	908
1909....	6,422	437	27	5	42.5	256	38,865	1,200
1910....	1,326	814	31	6	51.1	356	40,405	1,278
1911....	3,450	1,090	40	7	66.1	152	41,854	2,158
1912....	1,668	2,021	3	76	109.8	698	41,985	3,136
1913....	6,916	4,300	2	239	86.6	2,640	46,696	6,533
1914....	495,839	4,456	30	80	517.4	3,985	41,499	6,333
1915....	4,062,100	8,972	456	759	3,431.0	13,526	42,157	8,327
1916....	.....	14,537	53	.....	35.6	6,490	9,351	5,788
1917....	.....	8,772	.....	1	28.9	929	6,329	6,417
1918....	.....	5,647	.....	.....	22.9	172	16,210	826
1919....	.....	.....	.....	.....	40.4	.....	55,138	1,985
1920....	.....	.....	.....	.....	43.2	.....	71,298	1,412

(a) From *Sveriges Officiella Statistik Handel.* (b) Not reported. (c) Includes crude and manufactures. (d) Includes sodium cyanide. (e) Includes sodium and potassium. (f) Includes sodium bisulphate. (g) Metric tons. (h) Hectoliters. (i) Includes bicarbonate. (k) Includes tin chloride and tin oxide. (l) Includes sodium chlorate.

UNITED KINGDOM

The statistics of the mineral production, imports and exports, according to official reports, are given in the subjoined tables. Figures given in full-faced type are either provisional figures or estimates.

MINERAL AND METALLURGICAL PRODUCTION OF THE UNITED KINGDOM (a)
(In metric tons)

Year.	Alum Shale.	Arsenious Acid.	Arsenical Pyrites.	Barium Minerals.	Bauxite.	Chalk.	Clay. (c)	Coal.
1908....	5,459	2,007	3,270	39,572	11,904	4,329,983	14,638,710	265,726,332
1909....	9,266	2,926	182	42,436	9,652	4,508,136	14,293,598	268,007,890
1910....	6,781	2,187	958	45,384	4,208	4,705,766	(h)14,316,469	268,677,182
1911....	10,685	2,178	1,189	44,826	6,103	5,965,423	14,057,090	276,255,764
1912....	11,446	2,228	1,806	43,453	5,882	4,962,408	13,022,433	264,749,661
1913....	8,887	1,716	36	48,792	6,153	4,939,095	14,090,818	292,047,544
1914....	6,179	2,007	(b)	49,718	8,421	4,362,689	13,343,100	270,070,414
1915....	8,038	2,537	428	63,483	11,914	3,285,963	9,014,657	257,282,699
1916....	6,362	2,586	305	77,258	10,495	2,831,181	6,605,044	260,503,009
1917....	5,644	2,668	384	66,612	14,961	2,300,806	5,936,742	252,500,078
1918....	5,315	2,387	465	67,428	9,743	2,341,346	6,100,448	231,380,784
1919....	4,926	2,568	76	61,054	9,369	2,671,739	7,890,997	233,441,992
1920....	5,628	2,029	.....	65,183	11,197	3,807,494	11,208,008	233,227,547

Year.	Copper.		Fluorspar.	Gold.		Gravel and Sand.	Gypsum.	Bog Ore (Ireland). (c)
	Ore and Precipitate.	Fine.		Ore.	Bullion. *Kg.*			
1908.....	5,528	588	35,257	7,237	28.5	2,228,245	231,980	4,364
1909.....	3,777	442	43,165	5,627	37.6	2,199,583	242,832	2,719
1910.....	4,245	456	62,607	6,252	75.5	2,235,160	259,661	2,603
1911.....	3,314	398	56,117	2,796	13.2	2,311,694	281,125	2,743
1912.....	1,942	296	29,154	173	49.7	2,227,975	247,724	3,397
1913.....	2,108	428	54,557	4	4.9	2,449,305	242,341	3,899
1914.....	2,561	347	34,360	55	3.2	2,540,520	269,637	2,381
1915.....	835	238	33,656	5,169	39.1	2,388,106	251,209	2,018
1916.....	1,045	282	55,612	1,360	8.5	1,993,233	222,814	1,113
1917.....	1,178	190	65,918	*Nil.*	*Nil.*	1,960,224	175,800	1,765
1918.....	1,186	203	54,359	*Nil.*	*Nil.*	2,055,130	205,513	613
1919.....	378	146	37,453	*Nil.*	*Nil.*	2,081,417	208,141	154
1920.....	82	109	55,563	1	.....	2,801,441	291,598	.....

Year.	Iron.		Lead.		Manganese Ore.	Mineral Paints.	Oil Shale.	Phosphate of Lime.
	Ore.	Pig.	Ore.	Pig.				
1908....	15,272,273	4,925,250	29,718	21,336	6,409	15,643	2,938,456	9
1909....	15,220,408	(f)9,818,916	30,221	22,823	2,812	16,575	3,014,678	4
1910....	15,470,392	5,055,595	28,992	21,867	5,554	16,782	3,180,520	*Nil.*
1911....	15,768,511	5,101,089	24,186	18,279	5,067	14,819	3,166,838	.....
1912....	8,552,343	4,525,830	25,729	19,473	4,237	14,179	3,235,942	.....
1913....	16,263,950	5,224,607	24,656	18,462	5,480	15,387	3,333,048	.....
1914....	15,115,375	4,865,858	26,422	19,684	3,494	11,247	3,321,291	.....
1915....	14,464,196	4,640,885	21,078	15,770	4,716	9,134	3,046,930	.....
1916....	13,811,920	4,388,633	17,382	12,775	5,962	10,323	3,057,680	.....
1917....	15,084,750	(f)9,572,190	15,569	11,431	10,102	.....	3,167,852	.....
1918....	14,848,302	(f)9,184,974	15,003	11,084	17,737	5,275	3,126,387	3,426
1919....	12,451,406	(f)7,517,108	14,067	10,442	12,272	5,615	2,803,588	.....
1920....	12,912,065	(f)8,086,311	15,647	9,940	13,082	15,198	2,888,348	.....

Year.	Pyrite.	Salt.	Silica (Chert and Flint).	Silver. *Kg.*	Stone.			
					Igneous Rock.	Limestone. (d)	Sandstone.	Slate.
1908.....	9,600	1,873,555	64,813	4,207	6,211,860	11,977,007	5,105,481	420,979
1909.....	8,964	1,851,999	53,063	4,421	6,384,144	12,000,790	4,673,839	408,639
1910.....	10,393	2,083,543	75,089	4,251	6,714,774	12,713,565	4,456,679	423,006
1911.....	10,276	2,116,115	72,726	3,684	6,629,417	12,378,725	4,109,828	431,948
1912.....	10,691	2,157,621	75,963	3,955	6,748,852	11,692,338	3,903,560	389,812
1913.....	11,611	2,285,221	76,105	4,439	7,216,801	12,953,008	4,043,591	376,935
1914.....	11,848	2,103,316	77,483	4,555	7,250,120	12,361,082	3,520,306	324,227
1915.....	10,705	2,037,895	104,351	2,930	6,183,390	11,294,875	2,561,442	229,676
1916.....	10,650	1,992,011	51,407	2,690	4,921,151	10,711,292	2,031,497	179,674
1917.....	8,652	2,055,804	67,272	2,347	4,307,669	10,623,038	1,639,354	123,480
1918.....	22,552	2,007,828	55,396	2,477	4,025,304	10,734,224	1,578,157	111,971
1919.....	7,455	1,938,800	13,446	2,128	4,458,345	9,691,048	1,727,221	166,740
1920.....	6,766	2,193,120	.....	.....	5,711,184	11,408,585	2,535,411	218,735

Year.	Strontium Sulphate.	Tin.		Tungsten Ore.	Uranium Ore.	Zinc.	
		Ore, Dressed.	Block.			Ore.	Spelter.
1908.....	16,733	8,137	5,133	237	72	15,469	5,926
1909.....	14,267	8,422	5,282	382	6	10,061	5,828
1910.....	4,838	7,693	4,874	275	76	11,418	4,235
1911.....	5,963	7,870	4,950	270	68	17,935	6,196
1912.....	19,693	8,302	5,342	192	43	17,988	60,163
1913.....	18,732	8,494	5,376	185	96	18,073	5,920
1914.....	13,376	8,220	5,144	208	350	15,676	5,295
1915.....	650	8,275	5,048	334	83	12,254	4,162
1916.....	2,553	8,019	4,773	400	52	8,612	3,048
1917.....	2,618	6,682	3,998	245	13	7,604	2,779
1918.....	1,031	5,463	4,018	300	.....	9,003	3,297
1919.....	2,317	5,239	3,325	169	.....	7,045	2,475
1920.....	4,250	4,936	.....	95	61	5,146	.....

(*a*) From *Mineral Statistics of the United Kingdom.* (*b*) Not reported. (*c*) Bog ore, which is mined in Ireland, is an ore of iron, used principally for purifying gas. (*d*) Does not include chalk. (*e*) Includes China clay, potters' clay, and fuller's earth. (*f*) Includes production from imported ore. (*h*) Includes shale.

MINERAL IMPORTS OF THE UNITED KINGDOM (*a*)

(In metric tons or dollars; £1 = $5)

Year.	Alkali.	Asphaltum.	Borax.	Coal, Coke, and Pat. Fuel.	Copper.			Iron and Steel.		
					Ore.	Regulus and Precipitate.	Wrought, Unwrought and Old.	Iron Ore.	Pig Iron.	Scrap.
1908...	(*c*)13,732	(*b*)	(*n*)19,424	3,904	111,897	71,120	124,226	6,154,733	69,930	24,674
1909...	(*c*)10,857	(*b*)	(*n*)16,349	6,419	(*l*)90,579	(*l*)66,337	(*l*)133,758	(*l*)6,429,996	(*l*)111,300	(*l*)33,473
1910(i)	(*c*) 8,996	(*b*)	16,277	36,615	99,755	70,081	89,279	7,133,483	173,680	70,105
1911...	(*c*) 9,463	(*o*)14,415	20,621	30,672	87,986	65,914	101,059	6,448,462	178,167	51,096
1912...	8,812	(*o*)20,866	21,091	194,866	99,802	52,393	96,499	6,708,443	223,586	64,152
1913...	9,140	(*b*)	23,837	24,429	95,837	39,762	108,728	7,566,276	220,320	124,805
1914...	10,583	(*b*)	20,493	45,315	72,766	43,252	152,974	5,799,918	227,099	112,454
1915...	8,757	.....	21,672	3,843	38,766	39,011	183,393	6,306,547	202,500	115,125
1916...	7,789	.....	18,850	3,257	35,047	44,545	113,206	7,017,122	162,111	99,430
1917...	6,327	.....	13,740	4,382	16,821	28,696	145,077	6,289,308	157,674	28,841
1918...	95,104	.....	9,432	393	15,566	21,370	207,226	6,671,570	131,437	15,386
1919...	43,441	.....	13,740	1,115	15,774	17,616	116,864	5,286,470	166,327	113,929
1920...	.....	.....	32,167	1,658	31,666		114,289	6,605,576	217,556	442,719

Year.	Iron and Steel (*Continued*).								Lead.	
	Puddled and Wrought	Sheets and Plates.	Rails.	Strips, Wire, and Wire Rods.	Nails, Screws, Rivets, Bolts.	Steel Ingots, Blooms, Billets, etc.	Steel Bars, Shapes, Beams, Pillars.	Mnfrs. Unenumerated.	Ore.	Pig and Sheet.
1908..	85,270	56,652	31,393	109,313	54,251	437,238	231,859	$3,034,895	23,861	241,320
1909(*i*)	(*l*) 95,553	(*l*) 68,067	(*l*) 22,430	(*l*) 132,543	(*l*) 59,197	(*l*) 392,008	(*l*) 264,909	2,819,365	(*b*)	(*l*) 210,982
1910..	(*l*) 98,859	88,245	16,074	163,681	58,977	361,401	349,662	3,239,715	(*b*)	222,450
1911..	119,583	115,349	36,588	173,764	62,314	512,841	500,643	(*p*) 3,654,825	(*b*)	217,134
1912..	167,774	103,224	24,640	205,749	73,745	607,470	509,002	4,270,000	(*b*)	208,671
1913..	204,218	172,301	38,701	225,690	66,086	568,512	597,591	10,098,040	(*b*)	207,559
1914..	132,194	121,433	24,033	179,772	62,317	325,245	459,771	8,852,884	.....	227,931
1915..	46,775	31,016	15,956	199,558	65,410	453,617	108,939	8,678,975	.....	260,751
1916..	44,922	40,861	5,198	140,257	80,469	166,746	96,306	6,833,717	.....	160,529
1917..	28,776	18,807	222	83,538	51,700	59,342	66,329	5,465,405	.....	149,493
1918..	(*h*)	66,599	282	42,569	28,244	20,369	26,010	3,230,301	.....	212,296
1919..	33,400	12,630	9,884	113,137	38,389	71,883	39,629	12,262,750	.....	221,112
1920..	92,271	177,891	14,638	165,470	9,633	262,793	49,676	.....	.....	165,472

Year.	Manganese Ore.	Mica, Sheet.	Mica and Talc.	Paraffin.	Petroleum. *Liters.*	Phosphate Rock.	Platinum, Wrought and Unwrought. *Kg.*	Potassium Nitrate.	Pyrites of Iron and Copper.
1908.....	349,694	(*b*)	(*b*)	(*n*) 46,504	(*n*) 1,300,726,576	537,628	(*b*)	(*n*) 11,913	771,091
1909 (*i*)....	335,813	(*b*)	(*b*)	(*n*) 53,289	(*n*) 1,355,562,599	459,058	(*b*)	(*n*) 10,704	(*l*) 803,725
1910.....	489,948	(*b*)	(*b*)	(*n*) 54,073	(*n*) 1,308,396,240	462,905	(*b*)	11,558	825,284
1911.....	364,676	(*b*)	(*b*)	51,456	1,661,100,144	501,332	(*b*)	11,376	863,583
1912.....	393,798	(*b*)	(*b*)	74,836	1,879,486,588	528,620	(*b*)	11,034	921,717
1913.....	611,227	(*b*)	(*b*)	57,974	(*g*) 488,106,963	548,000	(*b*)	12,092	794,740
1914.....	487,426	.....	.....	53,576	(*g*) 646,894,523	564,865	.....	10,666	816,449
1915.....	383,613	.....	.....	93,677	(*g*) 588,469,699	380,883	.....	14,060	918,463
1916.....	446,585	.....	.....	75,217	(*g*) 451,931,774	338,738	.....	22,317	966,520
1917.....	336,597	.....	.....	73,811	(*g*) 826,895,171	281,070	.....	20,191	867,994
1918.....	371,492	.....	.....	59,171	(*g*) 1,324,495,125	472,229	.....	19,493	850,174
1919.....	270,079	.....	.....	64,120	(*g*) 723,026,780	357,481	.....	7,408	350,003
1920.....	459,900	.....	.....	69,065	(*g*) 880,207,568	531,776	.....	9,398	640,716

Year.	Quicksilver.	Silver Ore. (*d*)	Sodium Nitrate.	Sulphur.	Tin.		Zinc.		
					Ore.	Block, Ingot, Bars or Slabs.	Ore.	Spelter.	Mnfrs.
1908.....	1,483	$10,743,400	(*n*) 148,056	(*n*) 19,580	25,414	48,496	61,661	91,548	38,717
1909(*i*).....	(*m*) 1,469	10,409,800	(*n*) 91,650	21,211	(*m*) 24,471	(*l*) 42,393	(*b*)	104,217	19,280
1910.....	1,517	9,311,665	128,528	20,496	26,490	47,028	(*b*)	123,061	18,460
1911.....	1,584	8,420,954	130,549	21,269	29,300	46,643	(*b*)	117,077	19,417
1912.....	1,607	7,523,692	125,664	22,109	29,112	43,850	(*b*)	139,461	20,673
1913.....	1,543	5,718,552	143,275	18,518	35,169	46,443	(*b*)	147,421	19,081
1914.....	1,283	4,324,576	174,775	22,162	32,938	41,644	.....	117,660	12,690
1915.....	1,381	3,446,485	134,360	36,247	45,494	39,544	.....	75,762	8,170
1916.....	1,159	3,429,646	21,232	37,281	34,458	34,188	.....	54,183	3,729
1917.....	985	4,317,690	1,707	29,835	41,871	27,580	.....	77,330	4,171
1918.....	489	3,079,161	305	73,891	32,850	12,769	.....	68,242	.....
1919.....	1,289	3,797,075	24,879	7,695	36,312	23,271	.....	95,643	4,757
1920.....	1,281	4,477,177	149,850	16,013	34,354	29,212	.....	111,128	7,663

(*a*) From *Accounts Relating to trade and Navigation of the United Kingdom.* (*b*) Not reported. (*c*) Classified as soda compounds since 1901. (*d*) Includes the value of silver in argentiferous ore and metal. (*f*) Not separately enumerated. (*g*) Gallons. (*h*) Included in pig iron. (*i*) From *Mines and Quarries.* (*l*) From *Iron and Coal Trades Review.* (*m*) *Min. Jour.* (*n*) *Oil, Paint and Drug Reporter.* (*o*) From Trinidad. (*p*) There are besides, not here given, pipes, castings and forgings amounting to 51,000 tons.

MINERAL EXPORTS OF THE UNITED KINGDOM—DOMESTIC PRODUCTS (a)
(In metric tons or dollars; £1 = $5)

Year.	Bleaching Materials.	Cement.	Coal.	Coke.	Patent Fuel.	Supplied to Steamers.	Coal Products. (c)
1908	39,120	607,950	63,551,057	1,212,184	1,463,557	19,786,734	(n) 7,711,360
1909	(n) 46,321	607,825	64,089,132	(l) 1,180,218	(l) 1,479,142	20,029,427	(n) 7,276,050
1910(k)...	(n) 51,188	747,627	(l) 63,081,948	979,526	1,494,397	(l) 19,839,123	(n) 8,398,405
1911	46,416	727,092	65,636,084	1,076,887	1,638,625	19,573,379	£2,517,355
1912	41,989	656,460	65,479,346	1,042,489	1,590,557	18,584,946	£2,981,159
1913	36,928	761,232	74,623,453	1,254,502	2,087,407	21,382,032	£2,279,790
1914	30,458	608,344	60,023,878	1,202,562	1,634,553	18,844,505	£2,283,062
1915	25,086	432,243	44,260,350	1,027,140	1,245,489	13,858,147	£2,554,008
1916	8,794	416,602	38,969,013	1,505,350	1,346,023	13,197,282	£3,212,046
1917	2,650	363,441	35,559,219	1,299,232	1,550,843	10,392,422	£3,130,976
1918	3,074	202,522	32,264,126	930,667	1,529,321	8,897,455	£2,883,096
1919	17,725	392,069	35,817,086	1,532,289	1,735,514	12,214,784	£3,411,806
1920	22,044	630,400	25,333,256	1,699,865	2,294,267	14,063,190	£2,865,636

Year.	Copper.				Iron.				
	Ingot.	Mixed or Yellow Metal.	Mfrs.	Sulphate.	Ore.	Pig.	Scrap.	Cast Iron and Mfrs.	Wrought Iron, Shapes and Mfrs.
1908 ...	14,869	15,546	19,796	(m) 72,429	4,478	1,317,330	135,115	48,336	174,539
1909(k)	12,465	(m) 11,381	17,248	(m) 45,547	(l) 5,185	(l) 1,026,517	(l) 165,183	(l) 44,406	(l) 171,697
1910 ...	11,898	(m) 15,970	12,551	43,391	(l) 7,464	(l) 1,062,444	(l) 150,507	(l) 57,148	(q) 143,702
1911 ...	10,970	15,101	24,669	81,112	(l) 6,352	1,222,622	147,759	(l) 70,618	140,318
1912 ...	12,993	11,108	19,327	85,497	6,241	1,284,220	127,610	68,676	144,747
1913 ...	15,165	14,711	22,317	76,950	5,278	1,142,917	117,645	82,816	139,593
1914 ...	7,390	13,420	18,367	69,015	13,742	793,703	90,037	73,339	151,062
1915 ...	6,764	3,923	14,076	66,297	1,697	621,810	52,031	47,647	121,826
1916 ...	9,339	1,654	8,114	39,437	1,263	932,166	62,596	36,895	140,158
1917 ...	5,262	497	3,611	47,888	678	745,590	17,026	23,288	10,897
1918...	4,099	7,644	2,526	48,373	163	489,924	11,070	15,093	7,210
1919...	10,694	227	15,499	35,653	2,507	362,384	29,732	23,430	15,241
1920 ...	14,960	49,001	26,045	20,172	2,357	588,784	46,083	26,963	59,924

Year.	Iron (*Continued*).								
	Rails.	Wire and Mfrs. of.	Plates and Sheets.	Galvanized Sheets.	Black Plates for Tinning.	Tinned Plates.	Steel Ingots, Billets, Blooms, etc.	Steel Shapes, Beams, and Pillars.	Total Iron and Steel, and Mfrs. of.
1908 ..	589,525	95,801	210,526	396,366	62,079	409,335	2,452	278,792	4,162,065
1909(k)	(l) 589,499	(l) 107,406	(l) 169,918	(l) 502,791	(l) 61,025	(l) 446,781	(l) 3,217	(l) 309,555	4,278,172
1910 ..	490,068	(l) 124,703	(l) 197,858	(l) 606,530	(l) 56,691	(l) 490,733	(l) 3,340	(q) 230,850	4,661,647
1911 ..	381,320	(l) 129,252	(l) 203,850	627,215	(l) 68,137	492,104	(f) 4,376	231,793	4,588,385
1912 ..	418,742	121,215	218,585	669,252	66,775	488,629	4,241	245,033	4,891,270
1913 ..	517,251	118,814	204,452	774,948	72,977	503,170	4,942	255,580	5,017,456
1914 ..	451,030	100,938	145,017	576,044	58,192	442,755	5,784	328,061	3,946,688
1915 ..	257,552	64,407	250,400	291,187	54,383	374,742	16,106	555,115	3,248,454
1916 ..	55,263	53,281	340,741	119,097	139,138	326,890	84,186	642,469	3,349,294
1917 ..	39,813	49,791	259,474	19,225	13,685	180,071	435,650	74,627	2,366,330
1918 ..	27,354	19,010	231,597	8,977	4,647	227,062	162,109	65,303	1,633,993
1919 ..	127,832	59,690	377,850	189,097	33,034	294,426	253,429	59,188	2,260,806
1920 ..	136,722	121,226	342,391	417,548	36,896	359,419	371,391	99,664	3,305,602

Year.	Lead, Pig and Mfrs	Salt.	Sodium.				Tin, Block.	Zinc.		
			Soda Ash.	Carbonate and Bicarbonate.	Hydrate.	Sulphate.		Ore.	Spelter.	Mfrs.
1908 ..	50,221	532,101	(n) 83,713	(n) 20,805	(n) 73,769	(n) 22,974	9,486	3,833	8,537	(i)
1909 (k)	(m) 46,399	523,690	(n) 97,480	(n) 23,378	(n) 80,439	(n) 35,587	11,373	(b)	(m) 8,684	(i)
1910 ..	47,588	571,845	110,188	23,295	84,291	58,960	12,576	(b)	9,247	(i)
1911 ..	44,733	614,572	125,945	26,353	82,356	59,382	11,736	(b)	9,736	(i)
1912 ..	47,782	557,291	144,073	29,403	79,527	50,759	12,152	(b)	10,881	.....
1913 ..	49,261	542,157	159,714	39,175	76,152	67,504	11,687	....	11,313	.....
1914 ..	36,486	504,848	181,754	37,724	75,618	40,366	13,599	.....	7,580	.....
1915 ..	40,835	508,022	221,850	43,517	56,781	31,931	14,389	.....	2,428	.....
1916 ..	28,883	396,518	159770	45,268	29,670	24,760	18,315	.....	3,621	.....
1917 ..	9,466	313,603	162,852	29,961	25,383	21,070	19,597	.....	7,939	.....
1918 ..	4,997	259,382	171,526	23,005	22,295	30,047	15,483	.....	1,407	.....
1919 ..	25,982	350,768	171,559	36,634	26,660	26,581	14,859	.....	6,612	.....
1920 ..	35,185	390,325	227,891		48,347	103,524	13,550	.....	10,474	.....

(a) From *Accounts Relating to Trade and Navigation of the United Kingdom.* (b) Not reported. (c) Including naphtha, paraffin, paraffin oil and petroleum. (d) Previous reports not available. (e) Includes puddled iron. (f) Includes railroad material of all kinds. (g) Includes all soda compounds; not separate; enumerated previous to 1901. (h) Included under soda ash. (i) Included under spelter. (k) From *Mines and Quarries.* (l) From *Iron and Coal Trades Review.* (m) *Mining Journal.* (n) From *Oil, Paint and Drug Reporter.* (q) Bars only.

UNITED STATES

Of the following tables, the first records the imports of foreign mineral and metal products into the United States, whether dutiable or duty-free; the second shows the exports of materials produced in the United States; and the third reports the re-exports of products of foreign origin. These statistics are as reported by the Bureau of Foreign and Domestic Commerce, Department of Commerce, and special acknowledgment is due to the Chief of this Bureau, for furnishing the figures for many substances which are not reported in the Monthly Summary. The complete statement of production in the United States is given under the separate chapters.

IMPORTS (a)

Year.	Aluminium. Crude. Lb.	Kg.	Value.	Value per Lb.	Ammonium Sulphate. Lb.	Metric Tons.	Value.	Value per Lb.
1911	4,173,308	1,893,000	$598,272	$0.143	189,265,797	85,850	$5,066,470	$0.027
1912	22,759,937	10,326,650	3,092,889	0.136	119,085,120	54,049	3,447,225	0.029
1913	23,185,775	10,519,861	3,905,977	0.169	130,549,440	59,252	3,957,307	0.030
1914	16,241,340	7,369,029	2,729,383	0.168	166,031,040	75,356	4,475,603	0.027
1915	8,534,834	3,871,375	1,511,988	0.165	72,748,480	33,008	1,934,625	0.027
1916	6,646,385	3,014,734	1,729,298	0.260	29,034,880	13,171	954,815	0.033
1917	58,703	26,627	18,084	0.308	16,269,120	7,380	649,125	0.041
1918	1,800,436	816,660	569,150	0.316	6,704,320	3,041	425,881	0.063
1919	17,644,004	8,003,144	5,810,557	0.329	5,272,960	2,407	313,873	0.059
1920	40,074,132	18,177,225	11,880,176	0.297	4,466,560	2,026	247,495	0.055

Year.	Antimony. (p) Lb.	Metric Tons.	Value.	Value per Lb.	Antimony Ore. (r) Lb.	Metric Tons.	Value.	Value per Lb.
1911....	10,957,844	4,970	$573,564	$0.052	*Nil.*	.....	.....	.....
1912....	17,645,870	8,006	936,920	0.053	*Nil.*	.....	.....	.....
1913....	15,333,492	6,957	878,773	0.057	49,803	221	$1,739	$0.035
1914...	13,070,381	5,930	737,233	0.056	1,986,082	901	54,408	0.027
1915....	17,484,030	7,933	3,633,420	0.206	3,374,012	1,531	351,540	0.104
1916....	19,749,830	8,958	5,219,885	0.264	9,485,423	4,303	1,049,806	0.111
1917....	35,649,113	16,171	4,297,680	0.121	11,920,443	5,406	1,031,998	0.087
1918...	27,748,318	12,586	2,664,263	0.096	2,719,062	1,233	176,138	0.065
1919....	14,250,158	6,464	870,767	0.061	727,462	330	49,527	0.068
1920....	24,947,121	11,316	1,475,276	0.059	1,363,441	618	70,285	0.052

Year.	Asbestos. Crude, Value.	Mfd., Value.	Total Value.	Asphaltum. Long Tons.	Metric Tons.	Value.	Value per L. T.
1911 ...	$1,413,541	$161,442	$1,574,983	174,234	177,030	$778,185	$4.47
1912 ...	1,456,012	363,759	1,819,771	194,775	198,021	919,467	4.72
1913 ...	1,928,705	389,664	2,318,369	193,783	197,012	911,921	4.71
1914 ...	1,407,758	368,344	1,776,102	124,214	126,284	682,748	5.50
1915 ..	1,981,483	137,320	2,118,803	123,436	125,452	680,357	5.51
1916. ..	3,303,470	135,064	3,438,534	131,611	134,035	735,102	5.57
1917 ...	4,521,172	65,096	4,586,268	167,809	170,510	993,668	5.92
1918 ...	6,337,585	27,476	6,365,061	102,428	104,077	627,495	6.13
1919 ...	7,369,685	257,381	7,627,066	94,329	95,860	615,499	6.52
1920 ...	9,120,253	619,054	9,739,307	114,655	116,501	1,067,616	9.32

Year.	Arsenic. (b)				Barytes.				Bauxite.			
	Lb.	Metric Tons.	Value.	Value per Lb.	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1911...	9,246,263	4,194	$276,574	$0.030	20,860	21,195	$58,726	$2.82	43,222	43,916	$164,301	$3.80
1912...	12,964,946	5,881	447,431	0.035	26,665	27,093	79,315	2.97	26,214	26,635	95,431	3.64
1813...	9,726,216	4,412	419,134	0.043	36,875	37,490	99,564	2.97	21,456	21,814	85,746	3.99
1914...	7,267,372	3,297	274,387	0.038	25,598	26,025	77,265	3.02	24,844	25,258	96,500	3.88
1915...	6,373,624	2,891	268,194	0.042	3,404	3,460	15,613	4.59	3,421	3,477	17,500	5.12
1916...	4,322,321	1,961	232,720	0.054	146	148	2,317	15.87	30	30	87	2.90
1917...	7,909,045	3,584	674,875	0.085	84	85	1,806	21.50	7,691	7,815	28,989	3.77
1918...	14,996,140	6,802	1,439,223	0.069	*Nil.*	*Nil.*	*Nil.*	.....	3,653	3,712	14,791	4.05
1919...	13,080,573	5,933	941,181	0.072	105	107	594	5.66	6,082	6,180	36,820	5.99
1920...	15,640,000	7,094	1,216,651	0.078	22,209	22,566	146,858	6.61	42,895	43,586	251,284	5.86

Year.	Bismuth.				Chrome Ore.				Coal, Anthracite.			
	Lb.	Kg.	Value.	Value per Lb.	Long Tons.	Metric Tons.	Value.	Value per L.T.	Long Tons.	Metric Tons.	Value.	Value per L.T.
1911 .	172,093	78,061	$311,771	$1.81	37,529	38,131	$407,958	$10.87	2,463	2,502	$12,550	$5.10
1912 .	182,839	82,935	316,440	1.73	53,929	54,828	499,818	9.27	1,670	1,698	8,329	4.99
1913 .	117,747	53,424	213,257	1.81	65,180	66,266	627,821	9.56	921	936	5,697	6.19
1914 .	90,505	41,064	165,248	1.83	74,686	75,931	655,306	8.77	19,347	19,669	37,998	1.96
1915 .	44,362	20,122	108,288	2.44	76,455	77,704	780,061	10.20	2,998	3,047	14,922	4.98
1916 .	76,723	34,801	195,975	2.55	115,886	117,752	1,548,402	13.36	5,693	5,785	19,316	3.39
1917 .	69,250	31,411	142,300	2.05	72,063	73,223	1,098,659	15.25	11,188	11,368	46,523	4.16
1918 .	135,700	61,552	277,273	2.04	100,142	101,754	2,891,725	28.88	33,279	33,815	204,385	6.15
1919 .	57,607	26,130	55,179	0.96	61,404	62,393	1,381,497	22.49	73,945	75,135	522,419	7.06
1920 .	72,771	33,008	161,877	2.22	150,275	152,694	1,921,824	12.79	28,346	28,802	257,835	9.09

Year.	Coal, Bituminous.				Total Coal.		Coke.			
	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Value.	Long Tons.	Metric Tons.	Value.	Value per L. T
1911....	1,238,808	1,258,691	$3,611,518	$2.92	1,241,271	$3,624,068	69,515	70,631	$254,938	$3.67
1912....	1,608,350	1,635,156	4,509,636	2.80	1,610,020	4,517,965	110,347	112,186	488,691	4.43
1913....	1,413,857	1,437,421	3,856,811	2.73	1,414,778	3,862,508	93,507	95,065	442,687	4.73
1914....	1,375,316	1,398,238	3,889,821	2.80	1,394,663	3,927,819	120,777	122,790	555,548	4.60
1915....	1,521,237	1,546,085	4,398,425	2.96	1,524,235	4,413,347	47,520	48,296	222,382	4.68
1916....	1,530,212	1,554,848	4,714,433	3.08	1,535,905	4,733,749	49,067	49,857	249,514	5.09
1917....	1,293,262	1,314,084	4,795,110	3.71	1,304,450	4,841,633	22,207	22,565	146,451	6.60
1918....	1,301,229	1,322,178	6,694,081	5.14	1,334,508	6,898,466	26,936	27,370	221,880	8.23
1919....	903,170	917,711	4,950,686	5.48	977,115	5,473,105	14,720	14,500	140,653	9.86
1920....	1,111,598	1,129,495	6,733,676	6.05	1,139,944	6,991,511	36,735	37,326	403,175	10.97

Year.	Chloride of Lime.				Cement.			
	Lb.	Metric Tons.	Value.	Value per Lb.	Barrels. (c)	Metric Tons.	Value.	Value per Bbl.
1911.....	82,895,472	37,601	$667,804	$0.008	163,802	29,720	$254,258	$1.55
1912.....	74,235,256	33,682	597,002	0.008	65,064	11,808	93,583	1.44
1913.....	61,605,077	27,951	510,120	0.0083	77,333	14,035	134,187	1.74
1914.....	34,539,934	15,671	332,792	0.0096	115,770	20,920	193,155	1.68
1915.....	7,564,473	3,432	102,570	0.0135	40,097	7,275	57,149	1.43
1916.....	1,605,036	728	52,628	0.0328	1,714	311	4,924	2.87
1917.....	4,000	2	140	0.0350	2,207	400	6,075	2.75
1918.....	539,881	245	11,407	0.0211	287	52	1,185	4.13
1919.....	417,412	189	8,936	0.0214	8,081	1,466	51,363	6.36
1920.....	2,474,617	1,122	86,873	0.0351	473,134	85,848	1,229,431	2.60

Year.	Cobalt Oxide.				Copper, Ore and Matte.			
	Lb.	Kg.	Value.	Value per Lb.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1911.....	22,934	10,403	$11.047	$0.482	292,931	297,633	$6,935,794	$23.68
1912.....	31,848	14,446	15,132	0.475	499,549	507,875	12,696,532	25.42
1913.....	47,277	21,451	26,154	0.553	511,163	519,682	13,573,327	26.55
1914.....	227,886	103,397	220,593	0.97	417,222	424,176	12,172,138	29.17
1915.....	154,672	70,159	148,828	0.96	414,423	421,147	13,929,883	33.61
1916.....	206,639	93,756	192,009	0.93	631,168	641,330	29,799,581	47.21
1917.....	276,406	125,378	275,821	1.00	593,143	602,693	34,650,864	58.42
1918.....	208,596	94,617	291,699	1.40	493,675	501,623	34,334,820	69.55
1919.....	131,424	59,613	184,751	1.40	416,549	423,255	23,541,020	56.60
1920.....	202,704	91,944	399,605	1.97	414,636	421,312	21,890,449	52.79

Year.	Copper, Ingots, Old, etc.				Cryolite.			
	Lb.	Metric. Tons.	Value.	Value. per Lb.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1911.....	265,940,760	120,630	$31,540,827	$0.119	2,007	2,039	$47,093	$23.46
1912.....	305,369,592	138,552	44,259,727	0.145	2,126	2,160	48,293	22.72
1913.....	300,068,849	136,147	44,328,574	0.148	2,559	2,602	52,557	20.54
1914.....	201,549,503	91,447	27,813,866	0.138	4,613	4,690	94,424	20.47
1915.....	201,367,008	91,360	30,617,535	0.152	3,940	4,004	82,750	21.00
1916.....	287,548,126	130,429	65,384,132	0.227	3,857	3,919	165,222	42.84
1917.....	380,669,290	172,672	102,877,783	0.270	4,383	4,453	218,500	49.85
1918.....	418,588,634	189,868	99,103,163	0.235	1,950	1,981	97,500	50.00
1919.....	302,932,531	137,407	62,603,993	0.207	2,131	2,166	106,956	50.19
1920.....	369,233,636	167,481	67,822,990	0.184	3,864	3,926	193,638	50.11

Year.	Emery Grains.				Emery Rock.			
	Lb.	Metric. Tons.	Value.	Value per Lb.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1911....	712,134	323	$35,384	$0.050	10,232	10,396	$176,890	$17.29
1912....	791,667	359	32,876	0.042	15,793	16,052	284,585	18.01
1913....	2,496,372	1,133	114,806	0.046	17,122	17,377	342,809	20.03
1914....	761,674	346	30,017	0.039	12,662	12,873	255,554	20.10
1915....	569,639	258	22,655	0.040	8,313	8,449	180,594	21.72
1916....	217,725	99	9,286	0.043	7,511	7,632	102,459	13.64
1917....	240,764	109	14,654	0.061	650	660	8,875	13.65
1918....	623,241	284	32,499	0.052	4,956	5,036	148,228	29.91
1919....	392,789	178	22,432	0.057	8,302	8,436	235,596	28.42
1920....	.....	.....	.....	.....	5,398	5,485	222,321	41.19

Year.	Fuller's Earth.		Gold.		Iron Ore.			
	Long Tons.	Value.	In Coin and Bullion.	In Ore.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1911...	16,272	$143,594	$46,623,766	$10,821,418	1,811,732	1,840,810	$5,412,636	$2.99
1912...	17,062	145,337	55,789,906	10,758,866	2,104,576	2,139,652	6,499,690	3.09
1913...	16,632	146,001	51,618,628	12,086,204	2,594,770	2,638,016	8,336,819	3.21
1914...	22,302	195,083	46,311,059	11,076,682	1,350,588	1,373,891	4,483,832	3.32
1915...	17,349	152,493	438,302,822	13,651,768	1,341,281	1,363,189	4,181,645	3.12
1916...	15,001	139,664	672,588,232	13,402,002	1,326,864	1,348,226	4,570,875	3.44
1917...	15,174	176,417	536,945,793	15,508,581	971,663	987,307	3,655,392	3.76
1918...	11,256	165,535	45,790,718	15,868,386	787,468	800,146	3,464,304	4.40
1919...	12,387	189,711	59,789,616	16,844,430	476,461	484,132	2,385,689	5.01
1920...	17,174	221,893	414,255,260	17,018,724	1,268,536	1,288,959	5,191,369	4.09

Year.	Phosphates, Crude.				Pig Iron.			
	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1911....	16,153	16,412	$157,394	$9.74	148,459	150,842	$4,380,334	$29.50
1912....	28,821	29,284	231,255	8.02	129,325	131,481	4,770,730	36.89
1913....	26,408	26,833	206,719	7.83	156,450	159,058	6,557,095	41.91
1914....	15,178	15,431	136,526	9.00	139,683	141,218	4,694,186	33.60
1915....	5,359	5,446	50,606	9.44	89,836	91,303	4,108,180	45.73
1916....	4,612	4,686	36,389	7.89	135,349	137,528	10,239,868	75.65
1917....	92	93	1,169	12.71	76,786	78,022	7,872,105	102.51
1918....	*Nil.*	*Nil.*	*Nil.*	.....	34,711	35,270	4,968,056	143.12
1919....	34	35	457	13.44	101,665	103,302	6,565,106	64.57
1920....	.....	.....	.....	.....	196,364	199,525	12,849,119	65.44

Year.	Iron and Steel Scrap.			Bar Iron.		
	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.
1911.....	17,272	17,549	$190,285	26,730	27,159	$1,202,363
1912.....	23,612	24,006	256,710	26,112	26,547	1,151,853
1913.....	44,154	44,890	510,707	28,243	28,714	1,340,184
1914.....	34,849	35,430	277,818	15,015	16,688	625,365
1915.....	79,982	81,243	761,719	8,474	8,659	417,491
1916.....	116,039	117,907	1,140,704	7,701	7,825	647,393
1917.....	180,034	182,932	2,437,423	2,240	2,276	193,831
1918.....	70,419	64,757	1,341,343	1,469	1,493	194,597
1919.....	182,549	180,147	3,341,150	1,940	1,971	220,868
1920.....	140,645	142,909	2,915,589	4,987	5,067	677,182

Year.	Rails.			Hoop, Band or Scroll.			Ingots, Blooms, Slabs, Billets, etc.		
	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.
1911...	(f)	(f)	(f)	(f)	(f)	(f)	29,205	29,687	$2,772,614
1912...	3,780	3,843	$101,544	(f)	(f)	(f)	18,702	19,014	2,941,481
1913...	10,408	10,581	216,272	(f)	(f)	(f)	26,765	27,202	3,505,463
1914...	22,571	22,947	610,037	648	659	$23,702	40,189	40,845	2,943,047
1915...	78,525	79,808	2,088,532	*Nil*	*Nil*	*Nil*	14,998	15,243	1,941,501
1916...	26,299	26,722	740,109	*Nil*	*Nil*	*Nil*	26,142	26,561	3,239,642
1917...	9,263	9,412	307,139	*Nil*	*Nil*	*Nil*	44,198	44,910	3,948,936
1918...	8,705	8,846	341,985	*Nil*	*Nil*	*Nil*	41,070	41,735	3,700,157
1919...	17,008	17,282	651,830	*Nil*	*Nil*	*Nil*	16,266	16,528	3,848,745
1920...	45,684	46,420	1,922,409	*Nil*	*Nil*	*Nil*	24,232	24,622	4,892,600

Year.	Sheet, Plate and Taggers, Iron or Steel.			Tin Plates, Terne Plates and Taggers Tin.			Wire Rods.		
	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.
1911...	2,454	2,495	$275,498	14,089	14,324	$1,081,864	15,483	15,980	$731,291
1912...	3,299	3,354	363,141	2,053	2,087	229,891	15,069	15,320	726,205
1913...	2,893	2,941	381,593	20,680	21,025	1,478,635	16,098	16,366	802,401
1914...	4,310	4,382	514,080	15,411	15,668	1,049,297	6,954	7,070	373,615
1915...	1,416	1,444	218,954	2,350	2,389	196,328	5,317	5,403	331,724
1916...	1,730	1,758	345,622	1,008	1,024	214,574	4,130	4,196	509,559
1917...	1,748	1,775	526,788	124	126	31,453	1,060	1,077	221,184
1918...	1,517	1,541	632,558	32	32	5,964	7,677	7,800	621,936
1919...	1,096	1,114	455,559	242	246	66,944	342	348	63,572
1920...	1,791	1,820	589,199	400	407	130,143	5,488	5,576	746,953

Year.	Wire and Articles Made from.			Total Iron Imports. (e)	Lead in Ore and Base Bullion.		
	Long Tons.	Metric Tons.	Value.		Short Tons.	Metric Tons	Value.
1911	§	§	$1,270,426	$28,995,600	87,319	79,215	$3,452,695
1912	§	§	1,103,192	29,328,709	83,288	75,576	3,721,583
1913	§	§	1,167,368	33,601,985	57,105	51,817	2,962,139
1914	§	§	1,205,456	28,642,862	28,190	25,580	1,867,064
1915	§	§	640,521	20,380,093	51,086	46,358	3,431,829
1916	§	§	652,889	28,131,095	29,674	26,921	2,933,022
1917	§	§	348,786	25,882,335	72,478	65,752	8,879,980
1918	§	§	273,705	24,947,077	93,367	84,701	10,208,766
1919	§	§	463,054	26,880,164	65,799	59,793	5,453,537
1920	§	§	1,440,813	50,352,888	62,796	56,969	7,216,128

Year.	Lead in Pigs and Old.			Lead, Sheet, Pipe, Shot, etc.			Other Lead Mfrs.	Total Lead.
	Short Tons.	Metric Tons.	Value.	Lb.	Metric Tons.	Value.		
1911	2,632	2,388	$190,543	§	.....	.....	$9,834	$3,642,238
1912	272	247	19,917	31,284	14	$2,305	7,328	3,748,828
1913	41	37	3,678	§	§	§	17,138	2,982,955
1914	148	134	10,082	§	§	§	83,672	1,960,818
1915	410	372	28,154	201,510	91	17,059	131,635	3,591,618
1916	5,655	5,773	761,537	532	.....	63	106,119	3,800,678
1917	5,793	5,255	649,205	12,538	6	2,699	12,966	9,542,151
1918	5,240	4,754	645,281	6,892	3	624	37,391	10,891,438
1919	5,107	4,633	417,126	8,018	4	628	17,187	5,888,110
1920	35,719	32,404	4,019,684	81,396	37	5,483	27,313	11,263,125

Year.	White Lead.				Litharge.				Red Lead.			
	Lb.	Metric Tons.	Value.	Value per lb.	Lb.	Metric Tons.	Value.	Value per lb.	Lb.	Metric Tons.	Value.	Value per lb.
1911	741,071	336	$46,213	$0.062	24,662	11	$1,196	$0.048	1,163,533	528	$46,170	$0.040
1912	687,705	312	46,494	0.068	32,443	15	1,550	0.048	757,908	344	33,854	0.045
1913	671,839	305	48,266	0.072	34,023	15	1,750	0.051	99,562	45	4,903	0.049
1914	707,774	321	50,989	0.072	33,651	15	1,805	0.054	6,014	3	260	0.044
1915	339,157	154	24,608	0.073	20,650	9	1,422	0.069	1,968	1	132	0.067
1916	88,617	40	8,050	0.091	1,320	1	150	0.114	20,467	9	5,302	0.259
1917	20,238	9	1,965	0.097	*Nil.*	.....	.....	.....	50	.....	13	0.260
1918	158	.....	131	.....	100	.....	12	0.120	5	.....	1	0.200
1919	21,213	9	2,490	0.117	*Nil.*	.....	.....	.....	7,199	3	1,136	0.158
1920												

Year.	Orange Mineral.				Magnesite.			
	Lb.	Metric Tons.	Value.	Value per Lb.	Long Tons.	Metric Tons.	Value.	Value per L.T.
1911	504,734	229	$28,515	$0.056	120,133	122,061	$1,185,867	$9.85
1912	334,551	152	20,914	0.063	123,801	125,788	1,369,665	11.06
1913	330,525	150	22,205	0.067	161,012	163,696	1,757,476	10.92
1914	246,388	109	16,388	0.068	120,688	122,699	1,427,772	11.83
1915	171,572	78	14,061	0.082	68,159	69,272	647,241	9.41
1916	70,934	32	8,781	0.124	75,549	76,765	838,630	11.10
1917	33,294	15	4,892	0.147	30,574	31,066	464,706	15.20
1918	*Nil.*	.....	.....	.....	21,858	22,209	927,255	42.43
1919	39,781	18	5,082	0.128	14,153	14,381	374,032	27.01
1920	.....	.....	.....	.....	43,154	43,849	780,078	18.08

Year.	Manganese Ore.				Mica. (d)	Nickel. (h)	Nickel Ore and Matte.		
	Long Tons.	Metric Tons.	Value.	Value per L. T.			Long Tons.	Metric Tons.	Value.
1911.....	176,852	179,690	$1,186,791	$6.71	$469,089	$104,160	23,993	24,378	$3,918,556
1912.....	300,661	305,672	1,769,184	5.84	745,399	120,511	33,101	33,653	5,638,456
1913.....	345,090	350,842	2,029,680	5.87	981,601	(f)	37,623	38,250	6,427,639
1914.....	283,294	288,016	2,024,120	5.88	204,850	(f)	29,564	30,056	4,956,448
1915.....	313,985	319,040	2,633,286	8.40	244,292	19,929	45,798	46,546	7,615,999
1916.....	576,321	585,600	8,666,179	15.04	1,126,271	36,098	59,741	60,703	9,889,122
1917.....	629,972	640,118	10,262,929	15.92	1,368,020	50,011	61,053	62,036	9,612,400
1918.....	491,303	499,213	15,095,867	30.73	1,545,105	118,472	59,621	60,581	11,517,546
1919.....	333,344	338,711	11,229,184	33.68	1,632,884	2,643,882	23,057	23,428	5,780,380
1920.....	601,437	611,120	11,955,922	19.88	3,474,553	2,396,010	32,650	33,176	8,463,872

Year.	Oil, Mineral.			Platinum, Unmanufactured.				Platinum Mfrs.
	Gal.	Value.	Value per Gal.	Lb. Troy.	Kg.	Value.	Value per Lb. Troy.	
1911....	69,019,304	$2,406,581	$0.035	2,868	1,070	$1,278,293	$445.71	$3,587,998
1912....	309,765,930	6,033,231	0.019	3,692	1,378	1,716,630	464.96	2,777,853
1913....	731,360,523	12,997,011	0.018	4,283	1,599	1,978,770	462.01	3,065,489
1914....	724,446,909	11,500,730	0.016	2,676	999	1,154,955	431.60	1,818,668
1915....	763,705,698	10,563,628	0.014	4,644	1,733	2,077,536	447.35	334,472
1916....	890,853,850	13,887,263	0.016	3,436	1,283	2,506,531	729.49	650,788
1917....	1,324,157,815	20,604,606	0.016	2,179	813	2,095,390	961.45	319,765
1918....	1,635,597,145	25,669,795	0.016	3,819	1,426	4,144,740	1,085.29	819,240
1919....	2,274,771,088	31,440,627	0.014	3,996	1,491	4,556,353	1,140.23	690,169
1920....	4,569,341,185	65,902,780	0.014	4,818	1,798	6,050,868	1,255.87	2,518,039

Year.	Potassium Salts.											
	Chlorate.			Chloride.			Chromate and Bichromate.			Nitrate.		
	Lb.	Value.	Value per Lb.	Lb.	Value.	Value per Lb.	Lb.	Value.	Value per Lb.	Lb.	Value.	Value per Lb.
		$	$		$	$		$	$		$	$
1911....	27,856	2,450	0.088	509,119,193	7,651,684	0.015	22,408	2,159	0.096	7,945,747	265,061	0.038
1912....	99,919	6,787	0.068	482,265,665	7,229,109	0.015	32,913	3,085	0.094	7,315,531	216,492	0.030
1913....	1,191,461	64,468	0.054	478,826,857	7,120,055	0.015	18,629	1,819	0.097	9,876,910	262,575	0.027
1914....	27,406	2,235	0.083	371,520,195	5,745,385	0.015	31,858	2,375	0.075	2,229,856	74,743	0.034
1915....	16,001	3,666	0.229	129,346,560	2,297,149	0.018	32,942	2,902	0.088	127,270	28,095	0.022
1916....	10,199	7,189	0.705	2,598,400	348,961	0.134	459	75	0.163	11,537,033	1,519,375	0.131
1917....	1,006,740	404,783	0.402	1,366,400	158,410	0.116	2,404	962	0.400	9,217,004	667,209	0.072
1918....	709,805	248,160	0.350	848,960	102,109	0.120	20	8	0.400	9,349,305	907,279	0.097
1919....	199,077	34,996	0.176	46,403,840	1,783,916	0.038	15,450	4,271	0.277	37,726,254	1,115,484	0.030
1920....												

Year	Potassium Salts, All Other. (e)		Precious Stones. (f)			Pyrite. (i)			
	Lb.	Value.	Uncut.	Cut, not Set.	Jewelry.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1911.	155,140,643	$3,909,361	$9,963,393	$30,224,826	$1,470,167	1,001,944	1,018,025	$3,788,632	$3.78
1912.	131,049,932	3,185,098	9,979,582	26,218,261	989,288	964,478	980,553	3,860,738	3.88
1913.	124,519,551	3,253,245	12,630,037	27,626,937	998,723	848,674	862,819	3,611,136	4.00
1914.	.....	.....	3,008,823	13,652,861	775,364	977,372	993,662	4,706,383	4.82
1915.	41,109,008	1,461,637	7,124,316	14,161,769	387,150	974,616	990,531	4,817,977	4.95
1916.	6,578,291	449,538	11,522,198	26,420,425	307,510	1,244,519	1,264,556	6,728,318	5.41
1917.	9,373,123	1,780,883	13,573,806	20,168,954	252,730	967,340	982,914	5,981,457	6.16
1918.	9,752,991	2,717,386	13,210,076	8,729,904	185,939	498,786	506,816	2,767,448	5.55
1919.	5,429,582	675,642	21,939,280	69,228,979	726,574	388,973	395,235	2,176,565	5.59
1920.	.....	.....	14,245,494	50,476,638	1,361,572	332,606	337,960	1,660,832	5.00

Year.	Salt.				Silver.		Sodium Nitrate.			
	Short Tons.	Metric Tons.	Value.	Value per Sh. T.	In Coin and Bullion.	In Ore.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1911..	137,759	124,974	$378,083	$2.74	$16,351,154	$27,395,417	544,878	553,623	$16,814,256	$30.86
1912..	136,391	123,762	361,664	2.65	24,053,983	24,347,103	486,352	494,458	16,554,104	34.04
1913..	150,602	136,609	416,375	2.77	19,979,971	15,887,848	625,862	636,293	21,630,811	34.56
1914..	130,752	118,649	385,752	2.95	18,941,980	7,017,207	541,715	552,777	15,228,671	28.01
1915..	123,576	112,138	366,475	2.97	26,375,801	8,108,163	772,190	784,803	22,959,997	29.73
1916..	121,967	110,648	342,588	2.81	13,615,185	18,648,104	1,218,423	1,238,041	38,131,962	31.29
1917..	65,840	59,730	280,135	4.25	15,671,915	37,668,562	1,543,213	1,568,059	60,437,526	39.16
1918..	40,315	36,574	284,032	7.05	28,148,065	44,773,517	1,845,074	1,874,900	90,360,207	48.98
1919..	62,821	56,991	324,402	5.16	15,336,686	74,073,332	407,459	414,019	19,558,963	48.00
1920..	137,654	124,880	676,499	4.92	18,213,514	69,857,844	1,321,922	1,343,205	63,129,196	47.76

Year.	Sodium Hydroxide (Caustic).			Soda Ash and Carbonate.			All other Sodium Salts.	
	Lb.	Value.	Value. per Lb.	Lb.	Value.	Value per Lb.	Lb.	Value.
1911..	990,562	$34,281	$0.035	3,214,129	$36,252	$0.011	22,202,439	$303,934
1912..	884,204	29,461	0.033	3,393,354	39,912	0.012	7,332,392	232,808
1913..	696,158	25,888	0.037	2,962,180	35,872	0.012	7,518,125	263,162
1914..	535,883	21,607	0.040	3,130,366	51,869	0.017	.....	.....
1915..	244,806	15,058	0.062	838,609	13,369	0.016	.....	.....
1916..	154,223	24,606	0.160	1,015,010	29,134	0.029	3,557,120	564,473
1917..	146,236	17,773	0.122	2,063,571	70,080	0.034	12,807,367	1,431,919
1918..	2,002	193	0.096	1,445	29	0.020	4,107,012	420,754
1919..	42,724	6,888	0.161	829,266	12,998	0.016	11,881,033	882,231
1920..	97,798	11,970	0.122	1,515,278	37,161	0.024	24,171,224	2,909,290

Year.	Sulphur.									
	Crude.				Flowers.			Refined.		
	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.
1911..	24,250	24,639	$436,725	$18.01	3,891	3,953	$83,491	986	1,002	$24,906
1912..	26,885	27,333	494,778	18.40	1,310	1,331	39,126	1,665	1,692	40,933
1913..	14,636	14,880	278,056	19.00	5,899	5,997	115,574	1,233	1,254	29,091
1914..	22,810	23,190	409,537	18.39	621	631	17,214	1,800	1,830	47,568
1915..	24,647	25,050	405,990	16.43	647	658	23,046	988	1,004	30,335
1916..	21,289	21,632	358,416	16.84	425	432	18,408	455	462	15,020
1917..	973	989	20,176	20.73	*Nil.*	.....	.....	37	38	9,164
1918..	55	56	1,692	30.76	*Nil.*	.....	.....	27	27	7,850
1919..	77	78	1,997	25.94	*Nil.*	.....	.....	24	24	6,636
1920..	46	47	1,722	37.44	*Nil.*	.....	.....	92	94	25,106

Year.	Talc.				Tin.			
	Short Tons.	Metric Tons.	Value.	Value per Sh. T.	Lb.	Metric Tons.	Value.	Value per Lb.
1911...	7,113	6,453	$88,050	$12.38	106,936,872	48,506	$43,390,639	$0.406
1912...	10,817	9,813	121,541	11.24	116,003,385	52,633	50,371,102	0.434
1913...	14,004	12,702	143,500	10.25	104,282,230	47,315	46,900,314	0.450
1914...	17,869	16,210	202,415	11.33	95,049,612	43,126	32,861,188	0.346
1915...	18,069	16,396	199,840	11.06	115,636,332	52,465	38,736,909	0.336
1916...	16,682	15,134	218,180	13.08	138,073,293	62,629	51,803,384	0.375
1917...	16,132	14,635	257,454	15.96	143,636,782	65,152	63,628,940	0.443
1918...	12,697	11,519	251,102	19.37	142,507,393	64,640	93,144,218	0.653
1919...	12,973	11,769	250,248	19.29	89,698,391	40,686	50,890,019	0.568
1920...	21,729	19,712	442,732	20.38	126,038,389	57,170	73,786,765	0.585

Year.	Zinc.								Mfrs.
	Blocks, Pigs and Old.				Oxide. (j)		Sulphide.		
	Lb.	Metric Tons.	Value.	Value. per Lb.	Lb.	Value.	Lb.	Value.	Valu
1911	3,275,340	1,486	$170,634	$0.052	5,561,016	$ 357,466	6,355,312	$166,199	$124,9
1912	22,229,831	10,086	1,280,426	0.058	5,875,057	386,153	5,904,475	153,303	293,0
1913	12,199,267	5,535	660,706	0.054	6,865,094	433,886	5,066,535	152,980	62,2
1914	1,759,579	798	71,165	0.040	5,258,108	302,838	9,072,567	277,862	31,7
1915	1,808,964	821	131,468	0.072	1,764,887	154,149	4,251,772	144,567	15,7
1916	1,368,560	621	119,000	0.087	930,267	185,395	63,419	8,862	1,2
1917	513,153	233	25,849	0.050	248,047	53,525	9,990	6,519	5
1918	70,552	32	4,953	0.071	330,201	63,746	2,670	993	4
1919	139,182	63	4,500	0.032	216,380	45,689	10,035	4,413	1,5
1920	29,055	13	1,082	0.037	.....	.....	.....	.....	2,3

(a) From Summary of Foreign Commerce of the United States. (b) Includes arsenic sulphide and white arseni (c) Barrels of 400 lb. (d) Exclusive of ground mica. (e) Not including iron ore. (f) Not reported. (h) Include nickel oxide, alloys in which nickel is the principal constituent, and manufactures of nickel. (i) Containing mo than 25 per cent. sulphur. (j) Includes white pigments containing zinc but not lead, dry and in oil. (m) Includ bars of steel and steel forms not elsewhere specified. The high value is due to the value of "high-speed" ste (p) Matte, regulus, and metal. (r) Antimony contents of ore. (s) Not kainit. (t) Exclusive of pearls.

EXPORTS OF DOMESTIC PRODUCTS (a)

Year.	Aluminium and Mfrs. of.	Asbestos and Mfrs. of.	Cement.			
			Bbl.(i)	Metric Tons.	Value.	Value per Bb
1911	$1,158,603	$448,395	3,135,409	568,886	$4,632,215	$1.48
1912	1,347,621	601,701	4,215,532(p)	726,606	6,160,341	1.46
1913	966,094	754,102	2,964,358(p)	510,949	4,270,666	1.44
1914	1,546,510	513,037	2,140,197(p)	364,414	3,088,809	1.44
1915	3,682,117	764,050	2,565,031(p)	437,466	3,361,451	1.31
1916	15,417,134	1,215,209	2,563,976(p)	437,263	3,828,231	1.49
1917	14,586,467	2,049,131	2,586,215(p)	441,078	5,329,588	2.06
1918	10,869,388	2,544,378	2,252,446(p)	384,154	5,912,166	2.62
1919	3,890,326	3,689,394	2,463,573(p)	420,162	7,513,389	3.05
1920	5,630,520	4,572,203	2,985,807 (p)	509,229	10,045,369	3.37

Year	Coal.										
	Anthracite.				Bituminous. (m)				Coke.		
	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Metric Tons.	Value.	Value per L.T.	Long Tons.	Value.	
1911	3,553,999	3,611,041	$18,093,285	$5.09	13,878,754	14,101,508	$34,499,989	$2.49	914,042	$3,215,49	
1912	3,688,789	3,750,268	19,425,263	5.27	14,459,978	14,700,978	36,817,633	2.55	814,800	3,002,74	
1913	4,154,386	4,224,625	21,959,850	5.29	17,986,757	18,286,536	45,449,664	2.53	881,603	3,309,93	
1914	3,830,244	3,894,081	20,211,072	5.28	13,801,850	14,031,881	34,104,903	2.47	592,487	2,233,68	
1915	3,540,406	3,597,407	18,429,255	5.21	16,764,857	17,034,771	42,817,341	2.55	799,562	3,092,49	
1916	4,165,652	4,232,719	22,470,147	5.39	18,977,346	19,282,881	45,828,092	2.41	1,048,790	4,202,23	
1917	5,363,666	5,450,021	30,909,798	5.76	21,285,320	21,628,012	79,502,654	3.72	1,258,321	8,543,74	
1918	4,435,543	4,506,955	29,215,689	6.59	19,956,009	20,277,301	78,664,856	3.94	1,506,986	11,861,40	
1919	4,443,391	4,514,930	36,668,131	8.25	17,958,514	18,247,646	83,708,842	4.66	640,139	5,128,11	
1920	4,824,776	4,902,455	45,538,100	9.44	34,390,254	34,943,937	304,273,241	8.86	821,252	9,993,66	

Year.	Copper.									
	Ore and Matte.				Ingots, Bars, Plates and Old.				Mfrs.	
	Long Tons.	Metric Tons.	Value.	Value per L. T.	Lb.	Metric Tons.	Value.	Value per Lb.	Value.	Total, Except Ore.
1911.....	57,915	58,844	$2,352,080	$40.61	786,553,208	356,778	$98,168,182	$0.122	$5,159,664	103,327,34
1912.....	66,171	67,274	3,203,220	48.41	775,000,658	351,634	123,007,884	0.159	3,762,283	126,770,16
1913.....	65,684	66,779	2,973,997	45.28	926,241,092	420,255	143,353,624	0.155	1,555,493	144,909,11
1914.....	43,529	44,254	1,606,855	36.91	840,080,922	381,162	116,026,290	0.138	1,162,060	117,188,35
1915.....	57,731	58,660	453,125	7.85	681,917,955	309,311	117,250,816	0.172	7,885,472	125,136,27
1916.....	105,838	107,542	1,239,067	11.71	784,006,486	355,625	204,924,174	0.261	25,752,591	230,676,76
1917.....	67,721	68,811	1,615,960	23.86	1,126,875,368	511,139	337,107,796	0.300	16,957,876	354,065,67
1918.....	33,598	34,139	789,557	23.50	744,429,741	337,666	195,051,082	0.262	5,286,141	200,337,22
1919.....	3,003	3,051	128,541	42.80	515,959,108	234,034	117,288,514	0.227	4,557,812	121,846,33
1920.....	1,394	1,416	79,483	57.02	623,619,795	282,868	127,389,203	0.204	6,040,069	133,429,27

Year.	Gold.		Iron.							
			Ore.				Pig.			
	In Coin and Bullion. (c)	In Ore. (d)	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1911.....	$34,488,840	$499,265	768,386	780,719	$2,653,448	$3.45	120,799	122,738	$1,874,401	$15.52
1912.....	43,921,951	470,333	1,195,742	1,215,671	3,537,289	2.96	272,676	277,221	3,832,765	13.84
1913.....	88,331,790	602,781	1,042,151	1,059,520	3,513,419	3.37	277,648	282,275	4,026,306	14.50
1914.....	220,409,005	285,038	551,618	560,812	1,794,193	3.20	114,423	116,330	1,638,102	14.32
1915.....	18,902,237	419,330	707,641	719,034	2,181,629	3.08	224,509	226,891	3,667,167	16.33
1916.....	155,484,759	308,168	1,183,952	1,203,014	3,692,496	3.12	607,236	617,012	15,381,431	25.33
1917.....	371,362,421	251,463	1,132,313	1,150,543	4,464,111	3.94	656,220	666,785	24,037,051	36.63
1918.....	40,157,762	532,692	1,256,383	1,276,611	5,535,090	4.41	269,575	273,915	11,576,721	42.98
1919.....	368,164,529	20,719	996,569	1,012,614	4,308,746	4.33	321,261	326,433	12,313,183	38.32
1920.....	320,700,663	11,260	1,145,037	1,163,472	6,198,927	5.41	216,828	220,319	10,074,377	46.46

Year.	Iron, Bar.				Iron, Band, Hoop and Scroll.			Billets, Ingots and Blooms.			
	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Metric Tons.	Value	Long Tons.	Metric Tons.	Value.	Value per L. T.
1911....	17,683	17,967	$653,320	$36.94	3,731	3,791	$163,853	234,267	238,027	$5,150,518	$21.99
1912....	21,926	22,291	841,824	38.39	12,557	12,766	539,354	294,818	299,732	6,615,131	22.44
1913....	16,615	16,892	768,501	46.25	16,841	17,122	767,631	91,847	93,378	2,200,248	23.96
1914....	5,226	5,313	203,835	39.00	9,954	10,120	457,451	50,496	51,338	1,103,702	21.86
1915....	39,726	40,375	1,471,466	37.04	29,250	29,721	1,433,879	560,704	569,721	14,176,528	25.28
1916....	74,069	75,258	3,913,849	52.83	43,208	43,904	3,251,882	1,504,562	1,528,785	90,095,601	59.87
1917....	56,332	57,239	5,046,727	89.60	58,768	59,711	7,330,301	2,017,113	2,049,589	161,391,007	79.98
1918....	63,367	64,384	6,576,362	103.78	50,673	51,486	7,711,195	1,786,189	1,814,937	150,568,151	84.30
1919....	60,547	61,522	5,634,398	93.06	50,836	51,654	6,875,586	258,424	262,585	19,370,787	74.96
1920....	46,648	47,399	4,657,474	99.84	53,449	54,310	6,445,155	216,873	220,365	12,645,950	58.31

Year.	Iron, Nails and Spikes, Cut.				Iron, Nails and Spikes, All Other.				Iron, Plates and Sheets.		
	Lb.	Metric Tons.	Value.	Value per Lb.	Lb.	Metric Tons.	Value.	Value per Lb.	Long Tons.	Met. Tons.	Value.
1911	25,585,379	11,605	$470,515	$0.018	148,875,384	67,529	$3,279,105	$0.022	134,497	137,113	$8,353,089
1912	20,856,790	9,463	359,962	0.017	186,646,470	84,685	3,976,571	0.021	193,719	196,948	11,844,767
1913	8,488,503	3,851	165,068	0.019	132,014,432	59,898	3,031,967	0.023	98,978	100,628	6,568,413
1914	7,667,552	3,479	142,285	0.019	103,535,214	46,953	2,264,031	0.022	48,818	48,018	3,128,184
1915	9,487,774	4,304	190,667	0.020	255,562,644	115,923	6,048,240	0.024	101,449	103,082	6,603,002
1916	10,645,098	4,828	312,195	0.029	417,489,036	189,173	13,920,560	0.033	131,803	133,925	11,486,267
1917	10,136,192	4,598	434,766	0.043	348,214,785	157,947	17,965,560	0.051	148,723	151,097	20,748,607
1918	8,566,751	3,886	440,281	0.051	225,090,434	102,099	14,492,776	0.064	109,497	111,255	18,924,723
1919	6,542,341	2,967	393,284	0.060	292,956,260	132,877	18,278,862	0.062	141,532	143,811	20,061,836
1920	8,642,668	3,920	573,990	0.066	273,762,361	124,176	16,556,442	0.061	140,526	142,788	20,763,934

Year.	Pipes and Fittings.			Steel, Sheets and Plates.			Steel Rails.			
	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1911....	197,506	200,686	11,476,743	237,428	241,239	$ 9,800,215	420,874	427,629	$12,229,045	$29.05
1912....	249,853	254,476	14,256,406	352,802	358,682	14,508,622	446,473	453,914	13,053,774	29.24
1913....	301,790	306,649	17,999,990	364,448	370,522	14,472,711	460,553	468,229	13,979,549	30.35
1914....	199,621	202,835	11,020,557	232,078	235,946	9,308,312	174,680	177,591	5,103,918	29.22
1915....	176,933	179,779	10,210,439	318,154	323,276	11,764,484	391,379	397,680	12,095,170	30.90
1916....	228,573	232,253	16,183,989	383,755	389,933	23,046,571	540,828	549,535	20,417,582	37.76
1917....	204,719	208,015	24,142,769	683,015	693,980	84,543,248	512,669	520,923	24,023,090	39.94
1918....	145,943	148,293	21,659,554	715,380	726,864	90,325,377	453,537	460,839	26,402,864	58.25
1919....	275,535	279,971	40,407,502	887,479	901,767	77,916,180	652,443	662,953	38,986,855	59.74
1920....	353,188	358,874	53,527,742	1,000,845	1,016,958	94,195,241	594,634	604,208	36,066,505	60.65

Year.	Structural Iron and Steel.				Wire.				Steel Wire Rods.			
	Long Tons.	Metric Tons.	Value.	Value per L.T.	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Metric Tons.	Value.	Value per L. T.
			$	$			$	$			$	
1911 .	223,493	227,080	10,270,977	45.96	229,762	233,452	11,637,596	50.65	22,641	23,003	659,066	29.10
1912 .	288,164	292,967	12,694,804	44.05	244,711	248,790	11,536,442	47.14	64,978	66,061	1,898,986	29.22
1913 .	403,264	409,985	17,790,744	44.12	190,284	193,455	9,237,541	48.55	61,637	62,664	1,815,922	29.46
1914 .	182,395	185,435	6,961,636	38.17	180,842	183,856	8,568,589	47.38	61,856	62,887	1,810,389	29.27
1915 .	232,139	235,876	8,960,411	38.46	473,583	481,208	25,833,607	54.55	165,014	167,670	4,713,109	39.14
1916 .	300,594	305,434	17,541,862	58.48	683,025	694,028	52,224,940	76.46	158,284	160,832	8,109,111	51.23
1917 .	294,150	298,886	24,437,289	82.62	394,940	401,280	42,317,008	107.25	181,939	184,860	15,356,275	84.40
1918 .	232,729	236,476	21,468,452	92.24	392,301	398,599	44,197,043	112.66	148,522	150,906	12,469,715	83.96
1919 .	360,787	366,596	28,956,816	80.26	291,663	296,359	35,996,178	123.42	117,992	119,891	8,374,716	70.97
1920 .	493,605	501,603	38,394,552	77.78	320,679	325,842	41,427,122	129.20	116,770	118,650	8,884,854	76.09

Year.	Lead and Mfrs. of.	Nickel. (e)	Petroleum products. (In Thousands of Units.)*								
			Crude.			Naphtha.			Illuminating Oil.		
			M Gals.	M Value.	Value per Gal.	M Gals.	M Value.	Value per Gal.	M Gals.	M Value.	Value per Gal.
1911...	$680,419	$8,283,777	201,843	$6,165	$0.030	137,295	$11,483	$0.084	1,112,295	$61,055	$0.055
1912...	651,459	8,515,332	188,711	6,770	0.036	186,000	20,459	0.110	1,026,138	62,084	0.061
1913...	738,135	9,686,794	194,570	8,448	0.043	188,043	28,092	0.149	1,119,441	72,042	0.064
1914...	5,519,908	9,455,528	124,736	4,959	0.040	209,693	25,288	0.121	1,010,449	64,113	0.063
1915...	11,758,979	10,128,514	158,263	4,283	0.027	281,609	33,885	0.120	836,959	49,989	0.059
1916...	17,095,451	12,952,493	172,028	7,030	0.041	355,870	68,661	0.192	854,688	55,863	0.065
1917...	18,243,661	8,936,620	172,121	7,668	0.045	415,879	93,134	0.224	658,156	48,954	0.074
1918...	15,318,910	6,927,041	205,829	12,084	0.059	559,369	139,593	0.250	491,110	50,354	0.102
1919...	8,106,371	1,697,544	248,821	14,806	0.060	372,134	92,050	0.247	979,155	119,024	0.122
1920...	6,535,050	574,845	337,886	28,990	0.086	641,165	175,484	0.274	861,892	132,254	0.153

Year.	Petroleum Products. (In Thousands of Units.)*									
	Lubricating Oil.			Fuel and Gas Oil. (g)			Paraffin.			
	M Gals.	M Value.	Value per Gal.	M Gals.	M Value.	Value per Gal.	M Lb.	M Metric Tons.	M Value.	Value per Lb.
1911 ...	183,320	$23,337	$0.127	133,979	$3,882	$0.029	214,018	97.1	$7,048	$0.033
1912 ...	216,393	28,297	0.131	266,237	6,599	0.025	294,591	133.7	9,603	0.033
1913 ...	207,639	29,609	0.143	426,872	11,126	0.026	236,046	107.1	8,177	0.035
1914 ...	191,648	26,316	0.137	703,508	19,224	0.027	188,823	85.7	6,435	0.034
1915 ...	239,679	32,460	0.135	812,216	22,325	0.028	386,914	175.5	12,535	0.032
1916 ...	260,806	43,027	0.165	964,091	27,141	0.028	376,813	170.9	14,820	0.039
1917 ...	280,438	57,565	0.205	1,124,524	45,656	0.041	311,090	141.1	17,907	0.058
1918 ...	257,316	75,602	0.294	1,200,750	66,616	0.055	235,543	106.8	22,274	0.095
1919 ...	274,795	85,143	0.308	584,850	30,819	0.053	263,345	119.4	24,817	0.094
1920 ...	410,874	156,634	0.381	827,594	54,889	0.066	375,282	170.2	32,620	0.087

* For convenience in tabulating, the quantities of all petroleum products and their gross values have been divided by 1000.

Year.	Crude Phosphates.				Quicksilver.			Silver.	
	Long Tons.	Metric Tons.	Value.	Value per L.T.	Lb.	Metric Tons.	Value.	In Coin and Bullion (c)	In Ore (d)
1911....	1,246,577	1,266,585	$9,235,388	$7.41	21,841	10	$13,995	$59,756,121	$129,909
1912....	1,206,520	1,226,629	8,996,456	7.46	23,283	11	13,360	66,846,486	137,752
1913....	1,366,508	1,389,283	9,996,580	7.32	85,521	39	43,574	59,509,520	154,769
1914....	964,114	980,183	6,771,652	7.02	108,426	49	70,753	47,767,578	76,084
1915 ...	253,421	257,501	1,603,851	6.33	252,852	115	225,509	47,403,607	63,628
1916....	243,678	247,601	1,156,391	4.74	666,047	302	670,475	70,550,279	44,758
1917....	170,202	172,942	941,823	7.87	808,336	367	998,470	83,963,550	167,326
1918....	150,446	152,868	1,170,413	7.79	232,346	105	338,620	239,940,918	18,248
1919....	465,521	473,374	6,342,838	13.68	683,004	310	817,328	239,013,116	7,945
1920....	1,151,005	1,169,536	13,540,804	11.76	116,493	53	129,993	116,035,400	16,522

Year.	Zinc Ore.				Zinc, Pigs, Bars, Plates and Sheet.			
	Long. Tons.	Metric Tons.	Value.	Value Per L.T.	Lb.	Metric Tons.	Value.	Value. per Lb.
1911.....	16,322	16,584	$642,884	$39.39	13,744,212	6,234	$810,099	$0.059
1912.....	20,847	21,194	823,997	39.53	13,268,186	6,020	864,292	0.065
1913.....	15,815	16,079	631,991	40.00	15,565,324	7,062	955,667	0.061
1914.....	9,920	10,085	388,464	39.06	129,694,022	58,804	8,540,668	0.066
1915.....	743	755	35,276	47.48	251,348,910	114,008	31,556,838	0.125
1916.....	70	71	3,992	57.03	412,726,882	187,213	59,391,085	0.144
1917.....	1,179	1,198	63,043	53.47	436,947,774	198,195	50,765,389	0.118
1918.....	55	56	2,480	45.09	200,197,310	90,807	20,558,827	0.103
1919.....	*Nil*	.....	.....	.....	283,354,764	128,527	24,665,642	0.087
1920.....	*Nil*	.....	.....	.....	228,058,715	103,445	19,659,735	0.070

Year.	Zinc Oxide.			
	Lb.	Metric Tons.	Value.	Value per Lb.
1911.....	29,236,779	13,262	$1,051,311	$0.036
1912.....	34,128,163	15 484	1,247,702	0.037
1913.....	28,932,953	13,127	1,136,257	0.039
1914.....	31,183,369	14,148	1,408,525	0.045
1915.....	39,978,569	18,134	2,068,428	0.052
1916.....	27,883,602	12,648	2,394,709	0.086
1917.....	30,891,886	14,012	3,148,898	0.102
1918.....	24,841,747	11,268	2,779,507	0.112
1919.....	29,405,334	13,340	3,059,276	0.104
1920.....	22,327,830	10,128	2,151,544	0.096

RE-EXPORTS OF FOREIGN PRODUCTS (a)

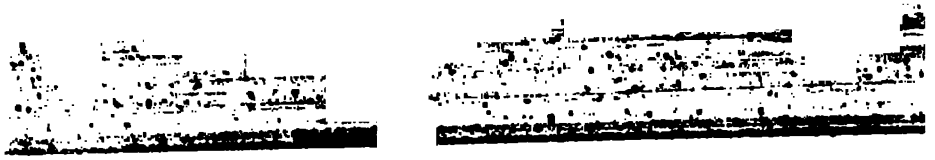
Year.	Antimony.			Antimony Ore.			Asphaltum, Crude.		
	Lb.	Metric Tons.	Value.	Short Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.
1911.....	160,844	73.0	$9,737	*Nil.*	*Nil.*	*Nil.*	3,402	3,457	$48,552
1912.....	(a)50,684	23.0	2,766	*Nil.*	*Nil.*	*Nil.*	2,589	2,632	62,276
1913.....	63,620	29.0	4,365	0.18	0.16	$ 22	1,282	1,303	25,954
1914.....	1,600,979	725.7	211,742	*Nil.*	*Nil.*	*Nil.*	21	21	387
1915.....	3,146,135	1,427.0	786,766	.....	.....	8	237	241	4,706
1916.....	3,018,251	1,369.0	761,045	231	209	9,874	97	99	1,568
1917.....	989,477	449.0	169,260	*Nil.*	*Nil.*	*Nil.*	17	17	715
1918.....	1,410,970	640.0	164,666	*Nil.*	*Nil.*	*Nil.*	659	670	9,483
1919.....	429,059	194.1	33,913	3	3	1,665	257	261	7,858
1920.....	896,030	406.4	51,607	*Nil.*	*Nil.*	*Nil.*	1	1	46

Year.	Cement.			Chemicals.					
	Bbl. (i)	Metric Tons.	Value.	Salts of Potassium. (f)			Chloride of Lime.		
				Lb.	Kg.	Value.	Lb.	Kg.	Value.
1911...	8,529	1,547	$14,095	2,731,792	1,239,133	$67,297	17,804	8,076	$241
1912...	4,586(p)	791	8,419	4,932,143	2,237,814	103,425	400	181	8
1913...	2,687(p)	460	4,075	8,660,837	3,929,599	162,467	13,260	6,016	333
1914...	757(p)	130	1,038	8,760,640	3,974,882	204,423	15,990	7,255	291
1915...	1,142(p)	197	2,209	3,005,825	1,363,433	279,660	120,126	54,489	2,496
1916...	625(p)	108	814	825,673	374,517	107,578	*Nil.*	*Nil.*	*Nil.*
1917...	*Nil.*	*Nil.*	*Nil.*	236,450	107,251	75,002	2,215	1,005	217
1918...	5	1	100	2,879	1,306	1,845	480	218	18
1919...	*Nil.*	*Nil.*	*Nil.*	2,099,968	952,524	165,116	495	224	52
1920...	*Nil.*	*Nil.*	*Nil.*	1,200,732	544,640	192,155	*Nil.*	*Nil.*	*Nil.*

Year.	Chemicals. (*Continued.*)											
	Nitrate of Sodium.			Sodium Cyanide.			Soda Ash and Carbonate.			Sodium Salts, All Other.		
	Long Tons.	Metric Tons.	Value.	Lb.	Kg.	Value.	Lb.	Kg.	Value.	Lb.	Kg.	Value.
1911.	6,787	6,896	$269,274	.....	.....	.....	.....	.....	....	611,922	277,566	$14,479
1912.	8,853	8,995	440,200	.....	.....	.....	.....	.....	....	431,407	195,685	9,418
1913.	5,560	5,653	295,111	.....	.....	.....	.....	.....	....	534,470	242,500	12,572
1914.	9,220	9,374	460,868	*Nil.*	*Nil.*	*Nil.*	.....	.....	....	.....	.....	13,862
1915.	22,743	23,109	1,123,761	1,897,727	860,790	347,079	.....	.....	....	.....	.....	40,358
1916.	53,453	54,314	3,432,273	222,916	101,112	58,625	.....	.....	....	.....	.....	193,085
1917.	69,779	70,902	5,367,281	276,801	125,654	115,067	.....	.....	....	.....	.....	25,632
1918.	54,706	55,591	5,204,413	125	57	145	.....	.....	....	.....	.....	73,402
1919.	13,673	13,893	1,299,563	*Nil.*	*Nil.*	*Nil.*	.....	.....	....	.....	.....	388,943
1920.	19,279	19,589	1,448,226	155,599	70,578	12,123	.....	.....	....	.....	.....	98,386

Year.	Coal, Bituminous.			Copper.						Graphite.	
				Ore and Matte.			Pigs, Bars, Ingots, Old, and All Unmanufactured.				
	Long. Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Lb.	Metric Tons.	Value.	Long Tons.	Value.
1911....	3,718	3,778	$10,296	*Nil.*	....	.....	200	0.1	$52	*Nil.*	.....
1912....	982	998	6,574	*Nil.*	....	.....	1,020	0.5	132	*Nil.*	.....
1913....	1,179	1,199	6,652	*Nil.*	....	.....	557	0.3	135	1	44
1914....	21,390	21,747	118,241	*Nil.*	....	.....	3,436	1.6	534	*Nil.*	.....
1915....	1,343	1,365	8,966	*Nil.*	*Nil.*	*Nil.*	801,872	364	151,369	.....	.....
1916....	24,257	24,648	77,001	2,739	2,783	55,675	7,629	3.4	1,529	.....	.....
1917....	5,150	5,233	33,336	5,898	5,993	118,213	61	.....	6	.....	.....
1918....	1,064	1,079	8,046	*Nil.*	*Nil.*	*Nil.*	1,400,630	635	357,535	.....	.....
1919....	2,082	2,117	12,597	*Nil.*	*Nil.*	*Nil.*	114,222	52	19,348	.....	.....
1920....	12,868	13,075	57,261	*Nil.*	*Nil.*	*Nil.*	3,346,106	1,518	604,461	.....	.....

Year.	Iron and Steel.											
	Pig Iron.			Scrap.			Bar Iron.			Rails.		
	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.
1911.....	1,837	1,866	$73,987	100	102	$1,373	12	12	$635	*Nil.*	.....	.....
1912.....	5,087	5,169	130,102	198	201	3,788	25	25	1,176	*Nil.*	.....	.....
1913.....	765	778	29,257	70	71	771	68	69	6,099	49	50	$1,000
1914.....	218	222	14,105	186	189	2,136	13	13	1,007	*Nil.*	.....	.....
1915.....	2,650	2,693	54,009	90	91	1,063	408	415	13,043	181	184	5,632
1916.....	961	976	63,555	244	248	4,667	24	24	2,137	19	19	503
1917.....	281	286	43,255	140	142	2,352	29	29	4,292	30	30	632
1918.....	1,443	1,466	286,165	*Nil.*	*Nil.*	*Nil.*	12	12	2,716	*Nil.*	*Nil.*	*Nil.*
1919.....	*Nil.*	*Nil.*	*Nil.*	30	30	827	21	21	5,289	.....	.....	.....
1920.....	839	852	76,070	82	83	1,710	8	8	1,575	.....	.....	.....



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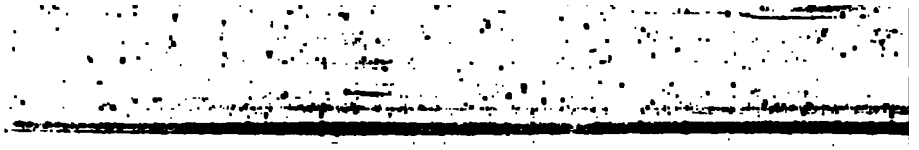
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